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Research in Gerontology

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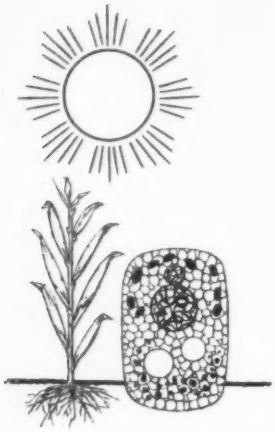

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The Need for Synthesizing

Science both prospers and suffers from a phenomenon peculiar to our times—specialization. Few scientists or research institutions, however, would have any desire to change the mode. And perhaps rightly so. The centrifugal tendency of the human mind to concentrate on a clearly defined focal point has wrought benefits too numerous and important to overlook. Undoubtedly new generations of Ph. D.'s will continue to follow the Newtonian method of pure inquiry in the specialized areas of their choice.

But by a strange paradox, the age of specialization has also brought a dilemma—the neglect of adequate and thorough synthesizing of scientific knowledge. In many areas of inquiry, science faces the predicament of being overloaded with documentation. And in such a state, the process of self criticism built into the literature of science faces the risk of becoming ineffective simply because there is too much to read. The nonsense becomes harder to weed out; the guidelines to scientific validity grow more indistinct.

Perhaps we need some system for deciding what should be kept and what should be consigned to limbo. More important, we need—as Weinberg says—to identify more clearly the criteria for scientific choice. Only on this basis can science continue to seek its support from society.

Finally, science might do well to reconsider the plea of Goethe, who, living on the verge of the age of specialization, implored scientists to search for underlying unity in their investigations. In our own era, with its emphasis on the multi-disciplinary approach and even more specialization, we dare not discount the importance of synthesizing knowledge to achieve that unity.

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Research in Gerontology:

Its Status and Needs

Dorothy Dickins

A GROWING concern for the welfare of the Nation's older citizens is beginning to develop in America. One of the reasons for this concern can probably be attributed to the fact that suddenly we have more older people in our population. Because of advances in medical science—improved control of communicable diseases, better nutrition, better sanitation—the death rate has been reduced. Today, more than 16 million people are over 65 years of age. And whereas a man at age 60 in 1900 could expect less than 3 years in retirement, today he can expect 8 or more years. The economic implications in such a situation are obvious; the solutions to the resulting problems are not so readily apparent.

A logical outgrowth of this concern has been an increased activity in the research aspects of gerontology. Both the U.S. Department of Agriculture and the State agricultural experiment stations are logically involved in this research, because of the high proportion of older persons living in rural areas. Moreover, an unbalanced age structure in rural areas is quite often either a contributing factor to or an outgrowth of declining economic stability.

What do we know about these older people, that is, those 65 years and older? We know of course that they are not a homogeneous group any more than people of any other age level. Some have relatively good physical and mental health. Others are physically and mentally infirm.

Ten percent of the total female population are over 65 years old, whereas only 8.5 percent of the male population are over 65. Three out of 5 women over 65 years are either widowed, single, or divorced. Most of these women are "on their own."

What does research tell us about adjustments that must be made by these older people? What have we learned about the problems they face in health and safety, housing, activities, finances, clothing, and food and nutrition?

FACTORS RELATED TO ADJUSTMENTS

THE growing number and proportion of older persons in our population has brought about a wide interest in the unique adjustment problems of this group. According to Tanes and Hansen (26) [1] activity in marital, social, organizational, leadership, and work roles appears to contribute to good social adjustment among people over 65. They show that 70 percent of the married and only 55 percent of the widowed over 65 years of age are well-adjusted. Also, more married persons than single, divorced, or separated persons are well-adjusted.

Leadership in office or committee work is strongly associated with good adjustment. Ninety-three percent of the leaders over 65 years of age were well-adjusted as compared with 57 percent of the nonleaders.

Good personal adjustment, as measured by the study (*26*), involves such things as feeling good about one's health, enjoying a number of close friendships, satisfaction with one's work, finding security or comfort in religion, feeling useful, and being relatively happy as compared with younger years.

Investigators reported that persons who think of themselves as middle-aged have better adjustment scores than those who say they are elderly or old. Those who feel they are in good health and economically secure also tend to be well-adjusted.

Factors that appear to be of little importance to personal adjustment after the age of 65 are residence (urban, rural), sex, and chronological age.

HEALTH AND SAFETY

OF all the factors that affect the aging population, health is probably the most important. Health is a complex problem associated with other social and economic circumstances. In general, research activity in this area is motivated by the premise that older persons for the most part have the capacity to lead independent and useful lives, but as a group they face the obstacles of ill health, physical handicaps, and perhaps sharply reduced income. Today we recognize that although persons may become more infirm as they become older, aging is a normal process and usually not incapacitating. Actually, estimates show that the proportion of the elderly who are chronically ill is low—from 2 to 4 percent of those 65 years of age and over.

Surveys on the health of the aged by both the Federal government and the State experiment stations have yielded meaningful information that will guide educational and action agencies in their programs. For example, a Vermont study (*20*) showed that 41 percent of the husbands, 48 percent of the wives, 42 percent of the individual men and 37 percent of the individual women believed they had good health. The question may be raised as to the validity of self-evaluation of health. However, Kutner and his associates (*16*) concluded that "older people cannot be said to be ignorant of their health conditions."

Half of the respondents in this study said their activities were not at all limited by disease or ailments, while one-third were slightly limited and one-sixth were extremely limited. Almost a fourth of all cases were overweight. This was true for 14 percent of the husbands, 20 percent of the individual men, 32 percent of the wives, and 20 percent of the individual women. Although a wide variety of diseases and ailments was reported, rheumatic diseases predominated and heart and circulatory diseases ranked next in importance.

Illness was correlated with age: 23 percent of those under 75 years and 34 percent of those 75 or older had been too ill to care for themselves at some time during the preceding year. More than a fourth (27 percent) of all respondents had nursing care for periods ranging from a single day to the entire year. The periods exceeded 2 weeks for 13 percent of all respondents.

As analyzed by Cowhig and Stewart (*10*), data from a national survey of farm-family living expenditures reveal the following significant points: (1) Per capita expenditures for medical care for those 65 years and older were consistently higher than those of younger families. The average per

[1] Italic numbers in parentheses refer to Literature Cited p. 10.

person medical expenditure for oldest families in 1955 was $92 compared to $59 for all other families. (2) Oldest farm families spent a higher proportion of income (12.6 percent) for medical items than did the youngest families (7.9 percent). (3) Oldest farm families least often reported dental expenditures (28 percent) or expenses for medical insurance (37 percent). (4) In general, hospital and surgical costs were greatest for the oldest families. Average expenses for families with any hospital costs were $235 for the oldest families and $106 for the youngest families. (5) Per capita costs were about one-fourth greater for urban than for farm families. (6) For both urban and farm families per capita expenditures were biggest for the oldest families.

We need more analyses such as this one to serve as a basis for planning comprehensive programs designed to meet the health needs of the elderly. Much valuable data stored away in files throughout the nation could be analyzed, correlated, and interpreted to add to our existing knowledge of the problems that accompany aging.

Beyer and Woods (*8*) give us some pertinent data on the influence of health on activities of older persons. In their study they asked the aged what physical problems were bothering them at present. One-third of the respondents indicated that they were not bothered by any problems. The percentage decreased significantly from 39 percent for those under 70 years to 24 percent for those 80 years and over. The most common ailments were arthritis and rheumatism. High blood pressure, hearing difficulties, eye trouble, heart trouble, and internal ailments ranked next. Seven out of 10 respondents stated they had not been confined to bed or the chair during the past year because of their health. The majority of those confined had been confined for less than a month, and this may have included several short periods throughout the year.

Thirty-seven percent of the respondents stated they had not given up any of the following activities because of their health: (1) working at their regular job, (2) taking long trips, (3) doing heavy work around the house, and (4) going up and down stairs.

The greatest differences between those living in their own households and those living in the households of others was in the proportion who had given up heavy work. This item became especially important with an increase in age. For those 80 years and over, 56 percent of the elderly living in their own households, compared with 77 percent of those living in the households of others, had given up some activity of this type.

In the Iowa study (*14*) each respondent was shown a card listing the more common chronic conditions of the aged and was asked whether he had any of these or any other chronic conditions not specifically listed. Ailments listed ranged from the less serious, such as hay fever and sinus infections, to the more severe, such as heart trouble, tuberculosis, and blindness.

About one-fourth of this population had no chronic ailments and slightly less than one-fourth had three or more. Chronic ailments were less prevalent in the urban zone than in the open country, but were most frequent in the village zone.

Many current research activities are directed towards obtaining information needed to improve safety programs and practices. Among those having relevance to accidents of the aged was one reported by Lawton (*18*). This research concerned falls of the elderly. Women over 75 years of age have more falls than any other age group. Clues from cinematographic studies indicate that these older women step down from benches and stools in a different manner than do men of all ages and women of young and middle age. It appears that men and younger women slip down in a slower and more muscularly-controlled, let-down manner than do women over 75 who drop down in virtually a falling step. These older women are not in complete control of their let-down, so that the unexpected presence of a tiny object or an irregularity in the floor can easily cause them to lose their balance and fall. Before the biomechanics of gait and stepping can be analyzed in detail, information is needed about shifts in the center of gravity. It is anticipated that the center-of-gravity shifts will be greater in the older age groups.

There are countless other studies of accidents and aging which need to be done. Some which have been suggested by Lawton are investigations of the role of temporary conditions, such as acute illness, the ingestion of alcohol, the use of medicine

and drugs, and variations in dietary patterns.

Research on the aging involves various problems of many dimensions which makes multidisciplinary approaches essential. Some of the research will be primarily physiological, some psychological, some anthropological, some biochemical, biophysical, or biomechanical, and much of it will require the combined efforts of scientists from a part or all of these disciplines before the problems can be solved. It is significant to note that a center for research on aging has been established in the National Institutes of Health. The Office of Aging, also an agency of the Department of Health, Education, and Welfare, conducts a continuing review and analysis of program needs, activities and accomplishments in the field of aging. Despite the work of these agencies, and that of the Department of Agriculture and other Federal agencies, and research by land-grant institutions, the health and safety aspects of gerontology will continue to demand the serious attention of researchers devoted to the task of relieving old age of one of its most serious burdens.

HOUSING

ONE of the more important needs of older persons is adequate housing of all types, within their ability to pay, and in areas in which they desire to live. Therefore, much of the research has sought to obtain answers to questions such as the following: What kind of housing facilities do the elderly need and want? Where do they want to live? With whom do they want to live?

A survey of 490 urban Pennsylvania families by Smith (*23*) showed that most persons do not want to live in a county home nor in the homes of their children when they grow older. They prefer to remain where they are.

When Beyer and Woods (*8*) asked the elderly what kind of living arrangement they thought was (1) "best for elderly people who take care of themselves", and (2) "best for the elderly who were no longer able to care for themselves," they obtained widely varying answers. Respondents, when asked about the elderly who could care for themselves, were given a choice of three living situations from which they could select one or volunteer a different choice. The three choices and the percentage of the total group selecting each were as follows: (1) Live by self away from relatives, 31 percent; (2) Live by self near relatives, 52 percent; (3) Live with relatives, 17 percent. Few volunteered a different choice.

Respondents, when asked about the elderly who could not care for themselves, were given four choices. Thirty-eight percent thought that the elderly should live in nursing homes when they are unable to care for themselves; 39 percent thought they should live in their own homes with nursing care; and the remaining (23 percent) thought they should live with their families. Very few mentioned the third category, "with relatives."

Beyer concluded from his study that older people do not want to live with their children, and that institutional living arrangements should be limited to the old and very old who are mentally or physically infirm. Such arrangements should be the last alternative.

Older people like to live in familiar surroundings where their friends and associations are. Most older farm people like rural surroundings with open spaces, a place for animals, a chance to watch things grow.

Many older people are not physically able to drive a car nor financially able to own one. Therefore, in these days of reduced public transportation, lack of transportation is a problem among older people everywhere. Stone (*24*) found that about one-fourth of the respondents in a Washington study felt their usual means of transportation was inadequate. Only 42 percent relied upon their own car as their usual means of transportation.

Many of the retirees included in Alleger's study (*4*) believed that living in or near urban centers and on 1 or 2 acres of land offered the most practical advantages for retirement.

Research on the housing of older people has revealed facts about the status of their dwellings. Many rural residents own their farms, but the houses in which they live do not meet present needs. Many dwellings are too large; others are poorly arranged. Some have poor structural conditions; many lack adequate facilities.

Cowles (*11*) obtained data on a variety of housing aspects of 429 aged persons. The 305 dwelling units in which the respondents lived averaged 6.2 rooms. However, 28.7 percent of the rooms in

their houses were not used, especially in winter. The older the person, the more noticeable was the tendency to use smaller areas of the house. Apparently old persons in higher age groups are more likely to be living in crowded quarters than those slightly younger. The problem of crowding was most frequent among the aged widows living with a son or daughter. Less than half the dwelling units of the aged surveyed in this Wisconsin study had running water, a flush toilet, and central heat. Usually, the older the person, the less frequently these conveniences were found in the dwelling unit in which they resided. In fact, the lack of conveniences was due in part to the great age of the houses in which the older persons lived, although in some cases it was due to the fact that the aged person lived with a son or daughter who had a heavy family load in addition to the parent.

The use and character of the stairs was a housing problem of importance to many older persons interviewed. A large proportion of the 305 dwellings (88 percent) had a second floor and almost all (95 percent) had basements. However, nearly one-half the stairs to the second floor and over a fourth of the basement stairs were not used by the aged.

Nearly a third of the dwellings in which the aged were living had no closets and about two-fifths had one closet only. In about two-thirds of the dwellings in which there was at least one closet, the old person shared the closet space with someone else. Often the older person, especially when living with children or persons other than a spouse, had no space to keep items other than clothing.

Beyer (*7*) likewise found deficiencies in the housing of older persons included in his study. Many were living in houses that were too large for them, both in terms of the number of rooms they needed and amount of space they could care for. Approximately 1 out of every 3 living in their own households occupied houses with 8 rooms or more. Most of those surveyed lived in units built before 1932.

Data from this Cornell study showed that dwellings were more deficient from the standpoint of their arrangement than from their structural characteristics. For example, more than one-third of the units rented or occupied rent-free by the elderly living in their own households did not have access to the bathroom except through another room. A significant proportion of these units also lacked a clothes closet in the respondent's room. Many dwellings had missing handrails from stairs and a significant proportion had no direct source of heat in bathrooms or bedrooms.

Supplementing the survey information on housing conditions of the elderly are recommendations from housing specialists (*2, 15, 19*). A report of recommendations made to the National Capitol Housing Authority for apartment units for low-income elderly occupants showed that elderly occupants can contribute many useful suggestions for improving their housing conditions. It also indicated that systematic studies of representative families in different areas of the country are needed to reveal the types of housing problems that require further research, and to serve as a basis for developing housing recommendations for nationwide use.

Design requirements, as worked out for the handicapped, might also be adopted for the feeble aged person. An example is the Illinois study (*19*), which developed space requirements and arrangements for wheel chair use in the kitchen.

Some difference of opinion prevails on what kind of housing is required to meet the problems of the older couple, the widowed spouse, the single person, or the ill. The first question is whether or not

a special type of housing is needed; the second is whether or not the aged should be segregated; and finally, how should housing be financed.

Authorities generally agree that, among retired persons who are not financially handicapped, (1) housing should conform to modern standards of comfort, (2) it should be fitted to their needs, and (3) the social environment should be such that the individual will continue to be a functioning part of the community. But it is more difficult to solve the problem for those unable either physically or financially to provide for themselves. Multiunit rental projects designed for the elderly could be built by nonprofit groups like churches or trade unions by using the specially-favorable terms of the Housing Act of 1956.

The surface has hardly been scratched in the housing field for senior citizens. New research needs to be initiated. Older people with little up-to-date information on housing and equipment must be kept informed about existing and proposed legislation on housing and living arrangements for the aged, as well as on research findings already available.

ACTIVITIES

As people become older their free-time activity assumes an ever-increasing position of importance in individual and social well-being. A number of investigators have obtained information about the activities of older people and the ways in which they spend their free time. This research provides a starting point in implementing public and private agencies with the knowledge for meeting the diversity of interests of all the aged.

Beyer (*8*) divides activities of the oldsters into two kinds: (1) activities involving obligated time and (2) leisure-time activities. Obligated-time activities include meal preparation, eating, and cleaning up, other housework, personal care shopping and related activities, gainful employment, and care of others. Most elderly persons had devoted a minimum of 5 or 6 hours a day to performing needed activities.

The median day for the group covered in this study was 15 hours long. This suggests that approximately two-thirds of the time during the day or about 10 hours was available for leisure or other work activities.

The three leisure-time activities in which a large proportion of respondents participated were watching television, visiting, and reading. In addition, a relatively high percentage of the elderly spent some time in idleness, just relaxing, or doing such things as "sitting and looking out of the window," and "napping."

Mornings were generally occupied with obligated-time activities; afternoons were spent primarily in a number of forms of leisure and idleness. Evenings were devoted primarily to television. No single activity was outstanding for the afternoon as was housework for the morning and television for the evening.

Langford (*17*) gives information about participation of oldsters in community activities. From a report of respondents' activities of the previous day, it was learned that one-third had had contact with the community on the previous day. This contact was generally for business and shopping purposes rather than for recreation and appeared in the largest percentage of cases for those living in their own households and those living in large communities. The survey data showed that a larger proportion of the aged desired to be closer to children than to any community facility. Little interest was expressed in being closer to parks, libraries, or movies.

Knowledge of the practices of older people is useful in planning programs for them: (1) It provides a tool for anticipating the likelihood of acceptability or use of new facilities or programs; and (2) It aids in differentiating between those who express lack of interest based on experiences and those who have had no exposure to ideas or experiences.

To leave full-time employment and enter a life unregulated by scheduled work requires an adjustment of major proportions. We need to have much more knowledge and to do much more work in this field of retirement of the aged. A standard other than chronological age could be established upon which to make decisions. According to studies in seven major cities by the U.S. Department of Labor, the over-65 workers in most jobs were able to compete with the younger workers; they were equally and sometimes more accurate, often more dependable, and no more difficult to

train or to supervise than younger workers. Retirement should be related to the desires of the individual and his ability to produce.

From a Vermont study (*21*) it would seem that women generally know how they probably will spend leisure time in their old age. Men, on the other hand, had given little thought to it. There needs to be more research in this particular area. Methods of getting people to think about retirement before it takes place might well be developed, as well as more effective guides in helping them plan for old age.

According to Alleger (*3*) nearly all older persons who lived some distance from neighbors felt the need of companionship. After a few years on the farm many wanted to be in or near an urban center where the church, the grocery store, and neighbors were within walking distance.

ECONOMIC FACTORS

THE economic factors related to increased age have assumed sharp importance within the last decade or so. Industrialization and technological progress have tended to limit employment opportunities for older persons on the grounds that they cannot stand the pace. Public and private pensions are usually not adequate to meet all retirement needs and are not likely to be so in the future.

What does research show about the economic status of older persons?

In a study by Beyer (*6*) older retired persons were asked about sources from which they received their present income. The most common source was Social Security. Next in importance were private pensions and returns on savings, although only one-fourth of the aged received income from each of these sources. In this study median income of couples was $1,600; of widowed or single women, $915; of widowed or single men, $1,270. For couples where the head of the household was still working full time in the job in which he had worked most of his life, the median income was $4,655. If he was working full time in a different job the median dropped to $3,735. If he was working only part-time it dropped to $2,420. For widowed or single women the medians dropped from $2,180 for full-time employment to $1,585 for part-time employment.

As might be expected, the aged in poor health in Beyer's study had lower incomes than those in better health. Both health and income had an important bearing on the housing situations of the aged.

In a study by Cowles (*12*) older persons were asked if they were able to meet ordinary expenses at present and if they would be able to meet unusual expenditures should they occur. Seventy-nine percent said they were able to take care of ordinary expenses, but only one-half of these felt that they would also be able to meet any unusual expenses. About one-fifth said that they were not able to care for their ordinary expenses and that they would find unusual expenses impossible to meet.

Rural Vermonters—50 to 64 years of age—were recently interviewed regarding preparation for old age (*21*). Few of these middle-aged couples had attempted to estimate probable income or probable financial needs of their old age. Many of the couples believed that they would be able to increase assets, but specific plans for doing so were rare. The one preparation for approaching old age which most of these couples had made was home ownership. They expected to have their homes free of mortgage before they reached old age.

Most of the Vermont couples had given no thought to where and how either spouse would live in case of the death of the other. Many of the wives had little understanding of their probable financial status in case of the death of the husband. The findings from this study indicate the need for the development of good financial plans for old age.

Budgetary aids for the aged should also be developed. According to Stubbs (*25*), many of the problems of retirement are directly related to poor money management. The older individual needs to know how to make wise choices between the many goods and services available in the American market. Stubbs states: "Those not enjoying a share of the national high level of living sometimes compensate for this by reaching for certain expensive status symbols that consume a large portion of their income."

The older family needs not only to know more about money management, but also goals on which to base these financial plans.

A study including 150 Mississippi farm families

showed that more younger than older women reported short-run and long-run family goals (*13*). It would seem from this study that there is a tendency for older farm families to stop striving and try to be satisfied with things as they are.

Lack of goals seems to be supported by a study made by Lawton (*18*) in which older persons were observed as pedestrians. Many older persons appeared not only to ignore danger but even to court it. Lawton explains this as follows: Many had outlived not only their families and friends but also their own anticipated life-span and their own life programs and had no future plans and no motivation to continue their now meaningless lives. Even injury offered a welcomed change. The ministrations of police, nurses, doctors indicated to them that someone cared and wanted them to continue life.

These studies clearly show that families need to "plan ahead" for the years when financial security is threatened by smaller income, inflation, higher medical bills, and other factors. Research might provide new methods and techniques to help people achieve sounder financial status in their declining years.

CLOTHING

IOWA home economists (*5*) have made some studies of clothing problems and behavior of older women. From the results of one of these studies it would seem that older women are definitely interested in their clothing. They want smartly-styled attractive garments and take pride in their appearance. They have a tendency to retain clothing attitudes and behavior from their middle-aged years. They also want about the same type of clothing which they consider suitable for middle-aged women except with some variation related to figure changes, physical disabilities, and changes in skin tone and hair color.

This study showed the need for more research to develop techniques for measuring clothing interest, for learning about clothing behavior, and for studying buying procedures of women of all ages over long periods of time to find out if changes are related to increased age. It is also reasonable to assume that there will be differences in attitudes of older women towards clothing just as there are differences in attitudes among younger women.

FOOD AND NUTRITION

RESEARCH on the nutritional aspect of older persons has been concerned mostly with studies of eating habits and appraisals of needs. On the basis of several studies, Adelson (*1*) concluded that most older folks select a nutritionally good diet, but a considerable number have daily diets that need to be increased in one or more nutrients. The most usual shortages are in calcium and ascorbic acid. Other nutrients that may be low are thiamine and riboflavin. Such faults occur in the diets of both men and women, but to a greater extent in the diets of women. The faults could be corrected by greater use of milk and cheese to increase calcium and riboflavin, citrus fruit and leafy greens to increase ascorbic acid, and bread and cereals to increase thiamine and riboflavin. More meat would also help raise the level of B vitamins.

In a study by Pudelkewicz (*22*) food selections from 7-day dietary records of 27 men and 62 women were appraised. Men averaged two servings or more of meat daily; women 1.75 or more servings. Fruits and vegetables appeared frequently on the dietaries of both men and women, but good sources of vitamin C were frequently not included. More women than men included a good source of vitamin C. Breads and cereals were a popular food group with men. For all ages beef was the most popular meat choice. Green beans was the most popular vitamin-rich vegetable followed by peas, cabbage, and carrots. Orange juice and grapefruit juice were the most popular fruit choices. Even though nutritionally balanced meals were available to some of the older people, they did not always eat the foods which would provide them with the basis for an adequate diet.

Bymers and Murray (*9*) reported that there was little evidence that older people find food marketing a particular problem. Shopping was usually done at nearby stores once or twice a week.

A problem often mentioned in connection with feeding older people is their poor food habits. Since the food we consume is important to mental and physical health at all ages, education in food selection should start early. As Dr. Edward J. Steiglitz, a geriatrics specialist, has well said, "We are today what we are largely because of yesterdays. The older we become the more yesterdays have affected us."

Can anything be done to improve the nutritional status of the older person who has inherited poor eating habits from his yesterdays? This problem has no simple solution. It involves much more than merely educating the aged in matters of diet and health. One must also consider the stigma of low income and possibly the intangible factors of the will to be healthy and the will to live.

SUMMARY AND CONCLUSIONS

ALTHOUGH research in gerontology has been limited, for the most part, to studies of the practices and attitudes of older persons, the findings have much significance in the quest of State and Federal agencies to help the aged improve their welfare. Highlights of the findings reviewed in this paper are as follows:

Health and Safety

One half the respondents in one State said their activities were not at all limited due to health, while one-third said activities were slightly limited and one-sixth extremely limited.

Per capita expenditures for medical care were consistently higher for those 65 years and older than for younger families.

Housing

Homes for nursing care should be limited to the old and very infirm. Most older people do not want to live in these homes or to live with their children. They prefer to continue living in their own homes as long as they are able.

Many of the dwellings in which older people now reside are too large. Others are poorly arranged and equipped.

Older persons have more suggestions for change in the kitchen than for any other room.

Activities

Older people interviewed in a New York study had a 15-hour day on the average, with 5 or 6 hours of their time committed to activities such as housework, gainful work, shopping, personal care, and eating.

Only one-third of the older people interviewed had had contact with the community on the previous day.

Compulsory retirement and travel limitations result in idle time for many older people.

Personal adjustment was more often achieved for older persons by living where public communication and transportation are nearly always available.

Economic Factors

Median income of older retired couples in New York was $1,600; of widowed or single retired women, $915; and of widowed or single retired men, $1,270.

Seventy-one percent of the older persons in a Wisconsin study said they were able to take care of ordinary living expenses, but only half of these felt that they would also be able to meet any unusual expense.

Most older people had made little or no preparation for old age, such as estimating probable income and probable expenses.

Older families had short- and long-run goals less often than younger families.

Clothing

Older women want about the same type of clothing which they consider suitable for middle-aged women with some variation related to figure change, physical disability, skin tone, or hair color.

Food and Nutrition

Studies show that most older persons have an adequate diet, but a number need an increase in one or more nutrients. Most usual shortages in diets are calcium and ascorbic acid.

Older people, even when provided an adequate diet, do not always eat the foods prepared for them.

Admittedly, we have learned much about the practices and attitudes of older persons from the kinds of studies reviewed in this paper. But research in gerontology obviously needs bolstering by more sophisticated and realistic approaches. We need to see older people in a more accurate perspective and in terms of their relationship to other groups. And, once we gain more knowledge about their problems, we cannot overlook the necessity for effective followup and educational programs.

Research workers in gerontology would do well to consider seriously these compelling needs in their future programs:

- Systematic housing studies of representative older persons in different areas of the country to serve as a basis for developing recommendations for nationwide use.
- Designs for kitchens and other areas.
- Further analysis of data now on hand to show factors affecting medical expenses of older persons.

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- More research on accidents and aging, on the order of Lawton's study of falls of the elderly.
- Multi-disciplinary approaches to the psychological, social, and economic problems of older citizens.
- More comprehensive studies on the food habits of the aged and whether anything can be done to improve the habits of yesterday.
- Development of research techniques for measuring clothing interest and for learning about clothing behavior. To what extent are changes related to increased age?
- Budgeting aids for the older group.
- Techniques to assist older persons in development of goals.
- Further study of retirement and the need for getting people to think about retirement before it comes.
- Research on what older people can do to earn money.
- More effective methods in guidance.
- Methods and techniques of communication most likely to reach older people and effective ways of working with older people and influencing them to accept recommendations from research.
- Studies of leadership potentials.
- Methods whereby present plans and activities for older persons can be better coordinated.

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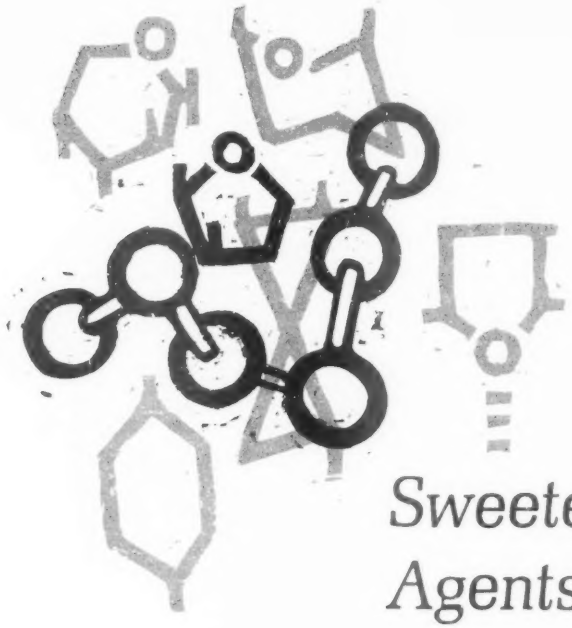


Sweetening Agents in Foods

The varying sweetness of sugars and other compounds as related to intramolecular hydrogen bonding and stereochemistry

R. S. Shallenberger

SWEET taste is an important adjunct of sugars. As a consequence, food scientists have directed much attention to the qualitative and quantitative description of sugar sweetness and to factors affecting this reaction in foods.

Concern with sugar sweetness has not been restricted to interests of food scientists alone. Psychologists have long pondered the phenomenon and have attempted, with considerable success, to quantitate the psychological response. Physiologists have studied the neurological response. Carbohydrate chemists, in turn, have been intrigued with large differences in sweet taste elicited by subtle differences in sugar molecular structure.

The perplexing feature of the sweet taste response is that it is not an attribute of the sugars alone, but is evoked by compounds belonging to nearly every chemical class. Inorganic compounds such as salts of beryllium (glucinum) and lead acetate (sugar and lead) taste sweet. Sodium chloride is reported to taste sweet at rather low concentrations, and sodium hydroxide has been reported to behave similarly (*3*) [1]. Simple naturally occurring polyols and sugar D-series generally taste sweet. Naturally occurring amino acids (the L-series) are more often tasteless or bitter, but the synthetic D-series may taste quite sweet. Many other organic compounds—the so-called "synthetic" sweetening agents—are intensely sweet and seem to bear very little chemical relation to each other.

To the food scientist, the general problem of sugar sweetness has its basis in both fundamental and practical problems in the food industry. For example, plant breeders selecting peas for sweetness find that there may be little relation between total pea sugar content and sweetness as determined by a taste panel. In the food industry, technologists disagree as to whether liquid or granular sucrose

[1] Italic numbers in parentheses refer to Literature Cited p. 20.

preparations are sweeter; whether invert sugar is sweeter than sucrose; or whether dextrose, corn syrup preparations, or cane sugar preparations are most appropriate for a given food product. The amount of sugar which should be added to some products during processing is difficult to assess because the appropriate level desired may be more closely related to a sugar to acid ratio, or to a sugar to salt ratio. Hydrophylic colloid content of the food may also be important since starches and pectins, for example, alter apparent sugar sweetness, although these materials do not have taste.

A difficult problem which often comes up in the food-processing industry, and which does not have a simple solution, is the level of glucose or dextrose preparations required to equal the sweetness of a standard amount of sucrose. A complicating factor is that relative glucose sweetness increases with increasing concentration. But the sugar, being more reactive than sucrose, may form complexes with other food components to alter its sweetness. In combination with sucrose, however, glucose may have a synergistic effect on sweetness. Some sugars taste sweeter at elevated solution temperatures, while others taste sweeter at a colder temperature. Glucose is an example of the former; fructose an example of the latter case.

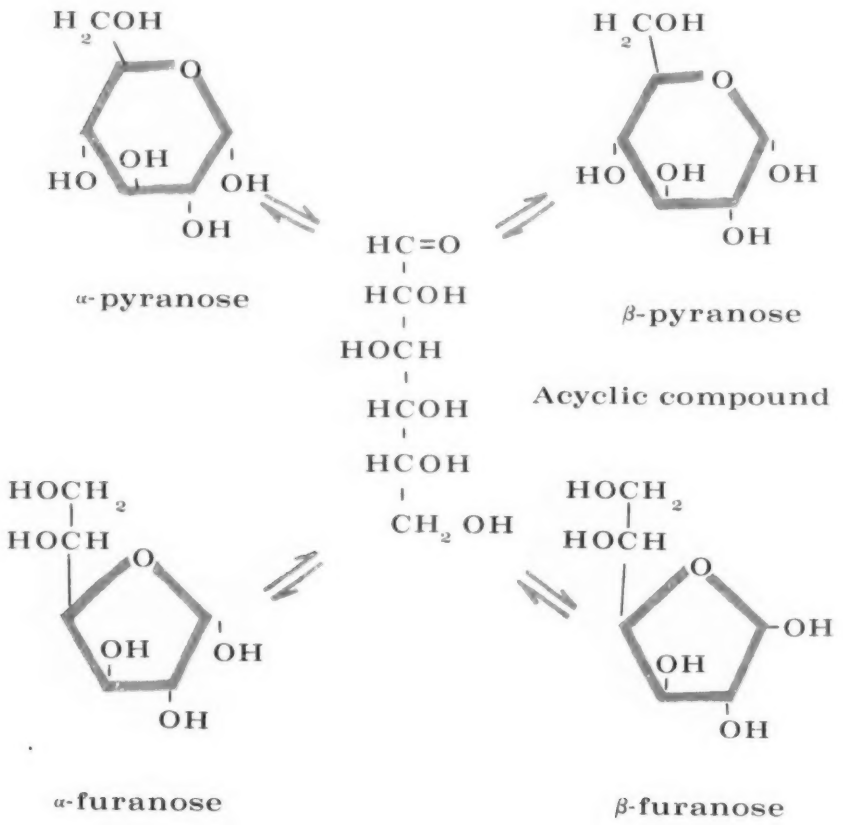
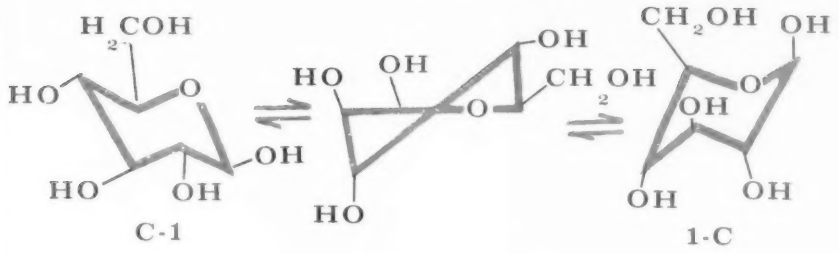


Figure 1

Figure 2



Half Chair

Apparent disagreement concerning sugar sweetness occurs in the literature. In some cases, the difficulty can be traced to incorrect specification of the sugar sample being studied, or failure to authenticate the identity or the purity of the material.

The physical state of the sugar is important. A sugar in solution may not have the same relative sweetness as when a few crystals are placed upon the tongue.

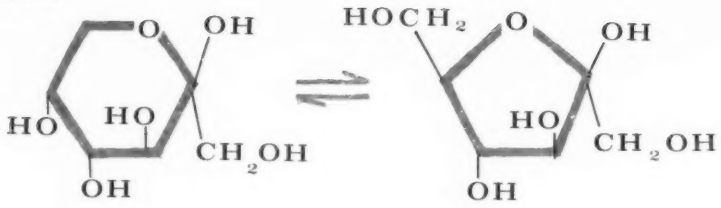
Sugars are usually listed in decreasing order of sweetness as fructose, sucrose, glucose, galactose, mannose, lactose, and raffinose. For crystalline compounds placed upon the tongue, such listings usually refer to the most common form of sugar commercially available. These are β-D-fructose, and α-D-glucose, -galactose, -mannose, and -lactose. The anomers of these sugars differ in their sweetness. Indeed, β-D-mannose is very bitter. Crystalline β-D-fructose is intensely sweet while crystalline α-D-lactose and the trisaccharide raffinose are tasteless. Because the α- and β-anomers of the sugars differ in their sweetness, it follows that, upon dissolution in water, the sweetness will change with time because of isomer interconversion to establish an equilibrium between the various forms possible. If, for example, a freshly prepared solution of α-D-glucose is compared with a mutarotated solution, the mutarotated mixture is not quite as sweet. The usual conclusion made is that α-D-glucose is sweeter than β-D-glucose. A specific problem is that such conclusions may be misleading, since sugars in solution establish an equilibrium between many isomers including α- and β-pyranose and furanose ring forms and the open-chain or acyclic form. For glucose, this may be illustrated as in figure 1.

Moreover, flexible pyranose ring isomers may establish an equilibrium between conformational isomers. In conformational isomers, the disposition of the hydroxyl groups is again greatly changed. For example, although β-D-glucose is known with certainty to exist entirely as the chair C–1 conformational isomer in the crystalline lattice structure, in solution it probably establishes an equilibrium, through a transitional half-chair form, with an unknown amount of the chair 1–C conformation (fig. 2).

Such considerations give some insight as to why the literature shows α-D-glucose to be sweeter than "β-D-glucose" in some instances (freshly prepared and mutarotated solutions are compared), while in others it is clearly shown the β-isomer is sweeter (crystalline materials, with fixed ring conformations are compared). True, crystalline sugars must first dissolve in the saliva before they can be tasted, but the sweet taste response is apparently much more rapid than sugar ring and conformation interconversion. Either crystalline α-D-galactose and α-D-mannose or freshly prepared solutions of these sugars are sweeter than either the β-anomers or the mutarotated solutions.

Fructose presents another specific problem concerning the sweetness of sugar anomers. Crystalline fructose is the sweetest sugar known. At the present time, the only known crystalline form is the β-D-fructoypranose isomer. In solution, mutarotation occurs, and in a direction which would suggest, by convention, the formation of an "α-anomer." Unlike other 6-carbon sugars, however, the change in rotation is primarily due to the formation of the furanose ring isomer (fig. 3).

Figure 3



β-D-**fructopyranose** β-D-**fructofuranose**

The furanose ring isomer is generally considered to be a β-anomer. An α-anomer of either ring isomer is not known, although gas chromatography of fructose silyl ethers suggests the existence of an α-fructopyranose in mutarotated pyridine solution. Hence, literature references to an α-β fructose equilibrium mixture really refer to an equilibrated mixture of β-D-pyranose and furanose isomers. Although crystalline fructose is about 80 percent again as sweet as sucrose, equilibrated water solutions are just slightly sweeter.

From the discussion presented above, it would appear that an initial approach to resolution of general and specific problems of sugar sweetness requires good knowledge of individual sugar structure and properties. Empirical rules and correlations between sugar properties and sweetness have been proposed by many investigators. In essence, however, there are very few general principles applicable to all known cases of sugar sweetness variation. As an example of a loose approximation, it can be stated that sugar sweetness diminishes with increasing molecular weight. Monosaccharides are generally sweeter than disaccharides, and these, in turn, are generally sweeter than trisaccharides. This principle serves to explain why pea sweetness does not necessarily parallel the total sugar content. Peas and other foods of legume origin accumulate, under certain conditions, considerable amounts of oligosaccharides (raffinose, stachyose, verbascose) which have very little sweet taste. Since these sugars all contain a sucrose moiety, they appear in conventional sugar determinations as sucrose. Unless chromatographic procedures are used for individual sugars, this fact passes unnoticed.

It has long been recognized that polyhydroxyl compounds tend to taste sweet, but there is little relation between the number of hydroxyl groups in a molecule and sweet taste (*1*). However, there does appear to be a good relation between the ratio

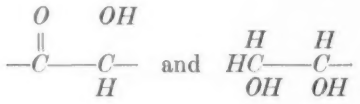
$$\frac{\textit{sum of atomic volumes}}{\textit{molecular volume}}$$

and the specification of sugar sweetness. Also, the ratio of the solubility of a sugar in water to the solubility of sucrose in water can be used as an index of sweetness. Because electronic molecular vibrations are purported to be the cause of taste in organic substances, sweet taste has been associated by Kodama (*2*) with "vibratory hydrogen." A similar line of reasoning by Tsuzuki and others (*7*) has shown that compounds having higher resonance energies are sweeter. Among sugars which can exist in two anomeric forms, it has been pointed out that sweet sugar anomers have a *cis* configuration between the anomeric and the adjacent OH group (*8*). This is not true, however, for the crystalline glucoses; β-D-mannose, which has the *cis* configuration, is bitter.

Several investigators have studied sugar sweetness with the hope of elucidating the saporous unit. Reinicke (*5*) concluded that sucrose sweetness depends upon at least "two oxygen tetrahedra in para position with two intervening carbon tetrahedra." I interpret this to indicate the ethylene glycol moiety.

$$\begin{array}{cc} OH & OH \\ | & | \\ -C- & -C- \\ | & | \\ H & H \end{array}$$

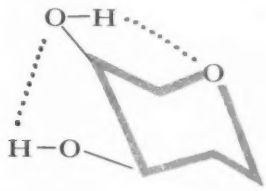
Soon after deWitt postulated that two types of groups—an auxochrome and a chromophore—were necessary to form a dye-stuff, Oertly and Meyers (*4*) postulated that in order for a compound to taste sweet, an auxogluc and a glucophore are needed. Of the glucophores mentioned, two are present in sugars:



The most recent attempt to resolve the anomalous and varying sweetness of the sugars also proposes that the sweet-tasting unit is the ethylene glycol moiety, and that the degree with which the hydroxyl groups are bridged by *intramolecular* hydrogen bonds is inversely related to sweet taste intensity (Shallenberger *6*). An analogy between the saporous unit of the sugars and of the synthetic sweeteners also appears in this theory.

A hydrogen bond, or hydrogen bridge, may occur whenever a hydrogen atom, attached to an elec-

Cyclohexane trans- 1:2 diol



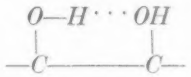
1-5-Anhydro-2-deoxy-L-erythropentitol

Figure 4

Auxoglucs pertinent to this discussion are the hydrogen atom and the methyl alcohol radical. This theory has been criticized because it does not account for the sweetness of the synthetic sweetening agents. However, both of the latter theories on sugar sweetness have one point in common. They point out that the sugar ethylene glycol moiety may be the unit contained in sugars which elicits sweet taste. The indication takes on added significance when it is recalled that ethyl alcohol does not taste sweet (although it has a fragrant aroma), while ethylene glycol is distinctly sweet.

Ethyl alcohol *Ethylene Glycol*

tronegative atom such as oxygen or nitrogen by a single convalent bond, is in the proximity of a second electronegative atom. Because the hydrogen nucleus is poorly shielded, it is displaced, and attracted to the second electronegative atom.



The strength of hydrogen bonds is small. They are, perhaps, not even $\frac{1}{10}$ as strong as single covalent bonds. Yet they may be quite significant in determining the properties of substances, particularly biological properties.

Evidence is available to suggest the probable existence of intramolecular hydrogen bonds between

sugar OH groups. Infrared spectra of the sugars yield multiple OH absorption bands, which indicates more than one type of OH group. Sharp distinct OH bands appear to be due to absorption by free OH groups. Broader, less distinct OH bands, occurring at lower wave numbers, appear to be due to bonded OH groups. Unfortunately, the only convenient way in which regular infrared data on sugars can be collected is to use the nujol-mull technique with crystalline sugar material. Intramolecular bonds cannot then be easily distinguished from intermolecular hydrogen bonds in the crystalline lattice structure. However, studies on diols, which are soluble in organic solvents and at concentrations which render intermolecular hydrogen bonding unlikely, show that the following bonds do exist (fig. 4 on preceding page).

By analogy with the compounds above, sugar molecule OH groups appear to be sterically located to be bonded either singly or doubly. The requirements are that the two oxygen atoms involved must have an O . . . O distance within 2.5 to 2.8 angstroms. Normally, adjacent sugar OH groups on the pyranose ring are *gauche* in the preferred chair conformations. Here, the O . . . O distance between the center of the oxygen atoms is 2.86 Å. If the OH groups are *cis,* they may, with the appropriate conformational change, approach an *eclipsed* arrangement. In the true *eclipsed* conformation, the O . . . O distance is 2.51 Å. Hydroxyl groups which are *cis* in the furanose ring isomers of the sugars are in a near *eclipsed* arrangement. Presumably, these OH groups would be capable of forming a rather strong intramolecular hydrogen bond (figs. 5 and 6).

Gauche hydroxyl groups

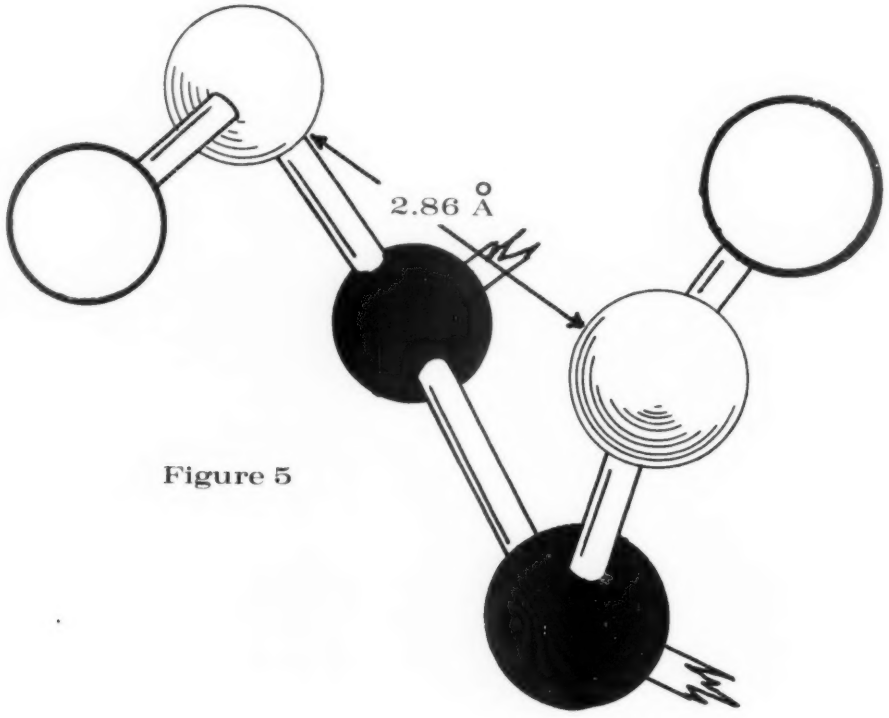


Figure 5

The varying sweetness of the sugars can be considered in the light of the above information. Galactose, for example, is the 4-epimer of glucose. Consequently, the hydroxyl group on carbon atom No. 4, being in an axial position on the pyranose ring, in the preferred C–1 conformation, is sterically located to be bonded by the OH group on carbon atom No. 3. It can also bond, by analogy to 1-5-Anhydro-2-deoxy-L-erythropentitol, the ring oxygen atom. An axial hydroxyl group on carbon atom No. 2 in mannose is similarly placed. Presumably then, an ethylene glycol moiety in these sugars is more strongly hydrogen bonded than in the epimer glucose, and they would not be as sweet. Taste tests show that galactose and mannose are only about one-half as sweet as glucose.

The anomers of glucose, galactose, and mannose present an interesting problem in varying sweetness. Crystalline β-D-glucose is slightly sweeter than α-D-glucose. But α-D-galactose and mannose are sweeter than the β-anomers. When the ability of these sugars to complex with boric acid is measured, the less-sweet anomers react more strongly. This reaction requires that adjacent OH groups must be in a near *eclipsed* conformation, or that the configuration will permit the *eclipsed* arrangement in one or more of the sugar conformations. Thus, the OH groups of the less-sweet forms of the sugars are closer together, or can come closer together. Hydrogen bonding between these OH groups would then minimize the ability of the group to elicit sweet taste response.

Eclipsed hydroxyl groups

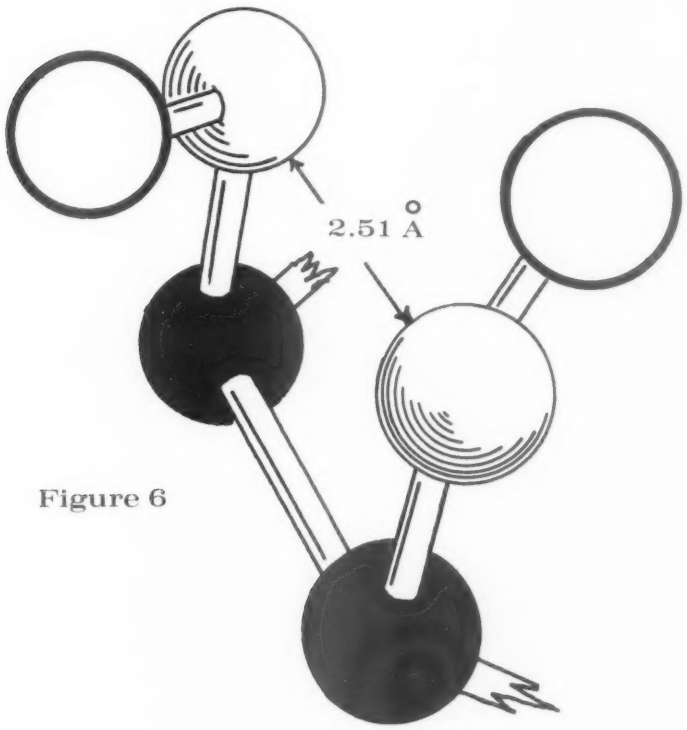


Figure 6

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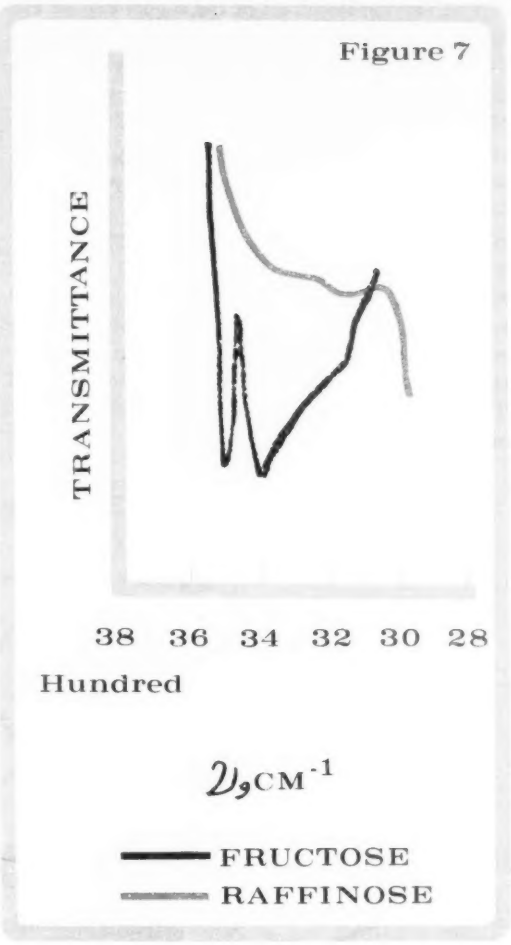
As mentioned previously, the furanose ring isomer forms when fructose mutarotates in solution. This compound has two *eclipsed* hydroxyl groups. Should a strong hydrogen bond form between these groups—as might be predicted since they are only 2.5 Å apart—this fructose isomer would completely lack the proposed saporous unit. It is understandable, therefore, why fructose solutions are only slightly sweeter than those of sucrose.

Infrared data on sugars indicates stronger hydrogen bonding in the less-sweet forms. Crystalline β-D-fructopyranose yields a very distinct hydroxyl absorption spectrum and has a sharp free OH band. Tasteless raffinose has one broad indistinct OH absorption band displaced toward lower wave numbers. These data are shown in figure 7. Spectra of other sugars lie between these extremes.

The presumption that sugar sweetness varies inversely with intramolecular hydrogen bonding makes apparent anomalous sweetness more rational. The relative sweetness of glucose solutions increases at higher concentration because the percentage of the α-anomer in the equilibrium mixture increases. It will be recalled that this isomer would not be disposed to assume a conformation which would allow stronger hydrogen bonding between OH groups. Glucose would also seem sweeter, with respect to sucrose at elevated solution temperatures because the bonds that are present are broken at elevated temperatures. By the same token, galactose can be made to appear nearly as sweet as glucose by increasing the temperature at which the comparisons are made. Fructose, on the other hand, behaves quite differently with respect to the concentration and temperature. At higher concentrations, or increased temperatures, the non-sweet furanose ring isomer is formed in greater abundance. Apparently, the hemiacetal bond closing the fructopyranose ring is more heat labile than the same bond in the furanose form, and also more labile than the hydrogen bond between the two *eclipsed* OH groups. Fructose solutions would consequently taste sweeter at lower temperatures. The impression that a cold, crisp apple tastes sweeter than one held at room temperature may have factual basis. Fructose is the predominant sugar in apples.

In the presence of hydrophyllic colloids, sugar sweetness may be altered because the OH groups

Figure 7



that elicit sweet taste when free are bonded instead to the same or similiar groups of the polymer. For sugar mixtures, intermolecular hydrogen bonding may throw the equilibrium between anomers in a direction favoring the form most likely to bond in this manner. For glucose, this would be the α-anomer. This phenomenom would serve as one explanation as to why mixtures of these sugars may seem synergistic in their sweetness action.

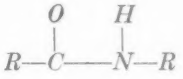
The one feature that the D-amino acids and the synthetic sweetening agents may have in common with the sugars is a saporous unit not unlike the ethylene glycol moiety. To cause sweetness, it seems apparent that two electronegative atoms must be in close proximity. One electronegative atom must be that of either an OH or NH group, or a potential NH group. Both electronegative

atoms must be either nitrogen or oxygen atoms. Figure 8 shows formulae for some common organic compounds (other than sugars) that are sweet.

There is little chemical relation between these compounds other than an NH, NH_2, or an OH group in close proximity to a second nitrogen or oxygen atom. It is also possible that closely related compounds other than sugars which vary in their sweetness, and in an apparent anomalous manner, do so because of intramolecular hydrogen bonding. One isomer of benzyl furaldoxime is reported to be 700 times as sweet as sucrose, but another isomer is only 100 times as sweet. Also, one isomer of perillaldehyde oxime is 2,000 times sweeter than sucrose while another isomer is tasteless. In the structural forumlae (fig. 9) intramolecular hydrogen bonding may be involved, although the actual site of the bonding is uncertain.

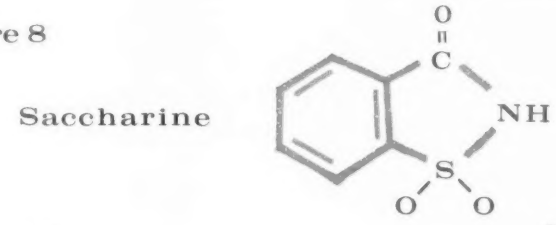
Possibly those compounds with an OH or an NH group sterically located to bond a second electronegative atom (or area of high electron density) may be less sweet. One isomer of benzyl furaldoxime may have the hydrogen atom of the OH group sterically positioned to form a hydrogen bond with the ring oxygen atom. One isomer of perillaldehyde oxime may have an OH group sterically positioned so that the hydrogen atom would be attracted to the double bond of the ring, which is an area of high electron density. Other examples of varying sweetness among the synthetic sweetening agents can be cited.

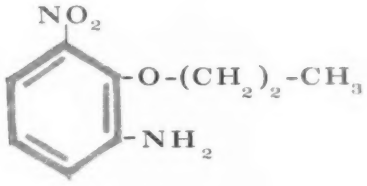
The D-amino acids have a saporous group of the type proposed, but the L-amino acids that are not usually sweet do also. Since these compounds have the same steric relationship between their atoms, this anomaly cannot be explained on the basis of intramolecular hydrogen bonding. However, it is implicit in the theory developed that the sweet taste response itself must in some manner be related to an intermolecular hydrogen bonding phenomenon between the saporous unit of sweet compounds and the taste bud receptor site. Should the site be an area analagous to the peptite bond of proteins,



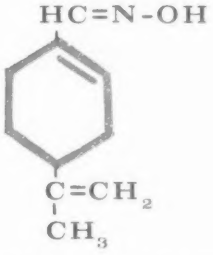
it would be commensurate with the saporous units of the sweet compounds discussed. Since the site would be constructed of L-amino acids, it is enticing to suggest that D-amino acids, which would fit the

Figure 8





2-propoxy-3-nitroaniline



Perillaldehyde oxime

site, would taste sweet, but that the L-amino acids would not generally taste sweet because they cannot be superimposed on the area because of steric features of the receptor site.

Sweet compounds such as dilute solutions of sodium chloride, lead acetate, and salts of beryllium cannot, of course, be fitted into this latest theory. One cannot help speculating on the "metallic" taste referred to repeatedly in the literature however. It is possible that the metallic taste, caused by positively charged metal ions, is an overwhelming extension of the sweet taste response.

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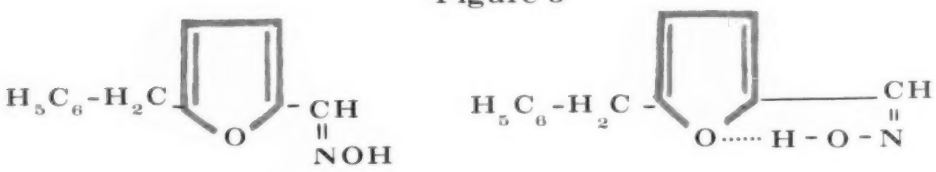
Figure 9



Benzyl furaldoxime isomers

Perilladehyde oxime isomers

Cold Acclimation

as it Relates to Winter Hardiness in Plants

D. G. Kenefick

A LARGE segment of the total agricultural production in this country depends upon over-wintering crops. During the period 1957–61, for example, there was approximately 3.3 times more acreage in winter wheat than spring types. In terms of production, winter wheat held a 7-bushel per acre yield advantage over spring wheat. Calculations based only on this yield advantage and the average annual acreage of winter wheat resulted in a figure which equalled the production of all spring wheats. From strictly a food production standpoint, in a world of expanding population, the impact of the winter wheat crop on the future food supply is obvious.

Another example of an important over-wintering crop is the perennial forages. About 80 percent of the total hay acreage for the 1957–61 period consisted of perennial types. A large part of the acreage was grown in Northern States where the livestock industry constitutes a major source of income for farmers and where length of the growing season limits the use of annual crops for hay. Perennial forages not only yield better than many annual types, but also are of high quality. Numerous other examples of over-wintering field and horticultural crops could be cited for their role in food production.

Photograph by Dave Warren

The advantages of over-wintering crops have many ramifications in agriculture. Some of the more obvious are: (1) Better use of the seasonal distribution of rainfall, (2) more efficient use of radiant energy by the extension of the growing season, and (3) a reduction of soil moisture losses, as well as soil erosion, by the presence of a crop canopy during periods of extreme environmental stress. Because of these features, there is a continued demand to expand the present geographic limits of wintering crops.

Regardless of the obvious advantages of winter crops, their cultivation entails many risks. Annual losses due to the direct or indirect effects of winter injury often completely eliminate crops in restricted locations and cause extensive damage in areas covering several States. Such losses are usually considered to be due to a general lack of hardiness or their vulnerability to winter chinooks or spring frost. Productivity of all winter crops could be increased far above present levels if some of these risks could be eliminated.

Although the economic advantages of winter crops are impressive, these factors alone may not provide sufficient basis for continued study in winter hardiness. Equally important is the feasibility of success of a research effort. Among other factors influencing such success is the development of theoretical and experimental evidence, as well as methods, in supporting disciplines. The discussion which follows is an attempt to evaluate present evidence and obtain a clearer understanding as to what may or may not be a scientifically sound approach to the winter hardiness problem.

ADAPTATION OF PLANTS TO FREEZING TEMPERATURES

Winter annual, biennial, and perennial plants require warm days, cool nights and shortening photoperiods to adjust to stresses encountered during the winter months. Such conditions are normally provided during the fall months before the soil freezes.

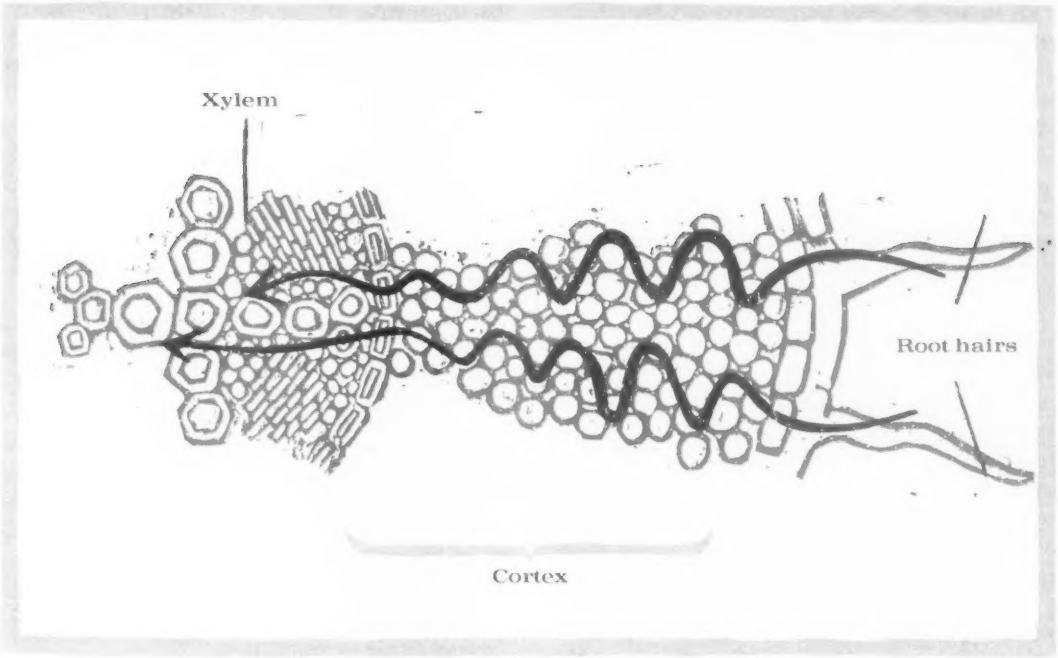
In addition to the importance of the acclimation process (hardening) in preventing freezing injury in plants, several features of this process make it desirable for investigation: (1) The basic conditions essential for plants to acclimate can be provided experimentally (*2, 8, 23*) [1]. (2) Physical and chemical changes can be compared in acclimated and nonacclimated tissue. Similar comparisons can be made on different genotypes and can be related to their known resistance, or experimentally established resistance, to freezing stress. (3) There is greater opportunity for objective treatment of data in comparison to an analysis of winter kill. Primary considerations are not complicated by secondary factors, which are likely important yet difficult to interpret in the case of injury. (4) In contrast to vernalization, cold acclimation is a reversible process and therefore the mechanism can be studied independently. Beside providing an experimental convenience, the reversible nature of acclimation imposes certain limitations on its beneficial features.

CHANGES OBSERVED IN ACCLIMATION

IT has not always been possible to demonstrate that experimentally acclimated plants can withstand freezing stresses of the same magnitude as those in the field. Several explanations could be offered for this difference, but space limitations do not permit such a discussion. For purposes of this paper the acclimation process is defined as the primary biological adjustment—the extent of which can be determined by a standard freeze test—which occurs during a 1-month acclimation period at 0–2° C. Such a limit is necessary to exclude other possible biological changes beyond this period that may or may not be the result of this primary adjustment to cold. The changes that occur during this period are of specific interest as they may be related to freezing protection in plants.

Other workers have not always made a distinction between changes during this primary adjustment period and subsequent changes. Not only is such convention experimentally necessary, but it would aid in eliminating much of the confusion that now exists in this subject area. Because of lack of distinction in the literature it will be necessary at times to use the words acclimation and winter hardiness interchangeably. It is assumed that winter hardiness is used in a more general sense and is a state of plants occuring any time after acclimation and until regrowth begins. As suggested above it is the most frost resistant stage, because of greater dehydration or other possible causes.

[1] Italic numbers in parentheses refer to Literature Cited p. 30.



The complex relationship between plant and environment has limited the amount of information that could be obtained by empirical methods. Even under relatively simple experimental conditions, where rate and intensity of freezing are controlled, it has been difficult to probe the mysteries of frost injury. A promising method has been developed to study changes in electrical resistance of plant tissue during freezing stress (*30*). It appears that the future application of this procedure will depend upon verification of some of the assumptions.

It is usually agreed that ice nucleation within cells is fatal. All plants can withstand a limited amount of ice in regions exterior to the cell. These facts suggest that acclimated hardy plants develop the ability to limit extensive ice nucleation or prevent the formation of intracellular ice. These ideas stimulated much of the earlier work on the role of soluble carbohydrates and proteins in protecting plants against freezing damage (*8, 23*). Plants subjected to moderate freezing conditions plasmolyze as a result of loss of water from cells (*4, 24*). Sherman (*35*) attributed the protective effects of substances such as glycerol to the actual withdrawal of water from mouse egg and bovine spermatozoa cells rather than a stabilizing force within the cells.

Investigations on cell fractions have been handicapped by the lack of precise information on intact tissue. In the use of *in vitro* methods there has been greater emphasis to demonstrate changes in tissue due to acclimation at the expense of determining the importance of such changes to the living system. The value of *in vitro* studies, however, rests solely on relating such data to the intact system. Without such information the distinction between cause and effect is difficult.

Several observations have been made regarding growth and physical appearance of hardy and nonhardy plants. The decumbent growth habits of hardy varieties under cool conditions, as well as distinct morphological characteristics, are good examples. Undoubtedly the association of dormancy with hardiness has its origin with some of these observations. The typical behavior of hardy and nonhardy types during freezing stress perhaps provides additional information. It has often been observed that acclimated hardy plants appear to wilt before nonhardy types in early stages of freezing stress.

Perhaps it is more than chance that nonhardy types continue to grow at low temperatures and even remain turgid under freezing conditions. Growth of cells in a broad sense depends on incorporation of water into cells which results in increased turgor. These gross observations strongly point to a need for a better understanding of forces involved in water distribution in tissue.

Plant Respiration and Carbohydrates

EARLY workers recognized the need for studies on the general level of metabolism as it pertained to winter hardiness. They postulated that fall dormancy was an essential criterion for freezing survival. This hypothesis was supported by numerous studies which demonstrated a slower decline of storage carbohydrates in hardy compared to nonhardy crops. These studies have been particularly valuable with forage crops as they led to the determination of a final harvest date which would insure adequate root reserves in the plants for the subsequent winter.

The relationship between carbohydrate reserves and hardiness in winter wheat varieties is not as pronounced as in forages (*23*). Newton (*28*), however, concluded from respiratory measurements on six winter wheat varieties, that an inverse relationship existed between hardiness and rate of respiration. He further concluded that the data substantiated conclusions regarding carbohydrate studies and degree of dormancy of hardy varieties. Calculations have been reported on the freezing-point depression of the plant extract, based upon the difference in levels of carbohydrate, which showed no significant osmotic effect in cells of hardy plants (*23*). The concentration of carbohydrates in critical sites in cells could, however, alter such calculations considerably. Extensive confusion still remains regarding the relationship of carbohydrates and rate of metabolism in winter survival.

Because of the impact of Newton's investigations (*28*) on winter hardiness, a brief discussion of some questionable aspects of this data is necessary. First, his measurements started in early fall and continued until late winter. During this period, the extent of tissue dehydration could have had a considerable influence on respiration. Such data were not included in his paper. Second, since CO_2 evolution was based upon dry weight of tissue, the changes in calculated respiration could have been due to the contribution of differing levels of carbohydrate (his argument) in the hardy or nonhardy tissue. Third, as the fall season progressed, the lower leaves of nonhardy varieties were damaged by freezing. These older leaves were removed and the respiratory rates of plants were compared with whole plants of the hardy type. Slight differences in tissue age might explain the small difference in respiration he reported. Finally, an evaluation of the reported experimental error in his studies certainly minimized the differences which were claimed. Some reservation must be made, therefore, regarding these data.

Even with the improved techniques available today for making respiratory measurements, some of the same problems exist. The determination of intact respiration may not be precise enough to make the fine distinction which could be attributed to the acclimation process. Newton (*27*) also attempted to determine the level of metabolism in winter wheat tissue by assaying catalase activity. Paradoxically, the hardy varieties had much greater activity (higher metabolic rate) than nonhardy plants. He chose to forego these results for the more comprehensive results on respiration.

Soluble Cytoplasmic Proteins

ONE of the more popular fields of investigation in cold acclimation and winter hardiness of plants has been the studies in protein chemistry. Most of these studies have been on the soluble proteins, because of the convenience of extraction and their assumed functions as essential enzymes in plant cells. The original association of cell proteins and winter hardiness evolved from knowledge of the colloidal properties of these molecules and their ability to "bind water." As enzyme chemistry became more prominent, the emphasis was placed upon denaturation of biologically-active proteins or their instability when water is removed. These hydration properties are characteristic of all water soluble proteins; a distinction is implied as to the degree or extent of hydration.

There has been a renewed interest in proteins partly because of the many new and delicate procedures and partly because of the recent genetic implications. Their function as enzymes provides a most intriguing field of study. Langridge (*19*) has

reviewed the effects of high and low temperature on enzyme systems. Research on cold acclimation in plants has not yet reached this level of refinement. It appears that an abnormal accumulation of specific end-products of metabolism in acclimated or frozen tissue might provide a sound basis for the initiation of enzyme studies.

Traditional approaches to the problem of the relation between winter hardiness and proteins have been more concerned with the physical properties of protein molecules. These approaches perhaps should be evaluated in light of developments in the area of protein structure. For example, denaturation of proteins has in the past been evaluated by precipitation from solution. It is now known that changes in molecular configuration can occur with no effect on solubility (*15*). It is not known how seriously biological activity is altered by these changes.

It appears that the older concept of hydrophylic proteins and "bound water" would play a lesser role in explaining winter hardiness than once advocated. Haurowitz (*13*) has stated that water bound to proteins beyond the primary layer is bound by energies lower than those involved in thermal movements of water. As indicated previously, solubility characteristics are determined by polar groups. Kauzmann (*15*) has suggested that nonpolar side-chains in proteins may be an equally important stabilizing force in the presence of water.

Perhaps a more practical consideration at this point, though, is the relative ease with which proteins may be altered during freezing stress and extraction procedures. The intrachain peptide hydrogen bonds within the helix, for example, are subject to continuous attack from water molecules (*36*). Hydrogen bonds are extremely important to the tertiary structure of soluble proteins (*15*) and are the primary forces in the structure of ice and water. The strong hydrogen bonding tendenices of water thus make it an undesirable extracting solvent for most proteins. It would appear that plant proteins, susceptible to denaturation by freezing stress, would also be the most difficult to extract in an unaltered state. Monitoring for enzymatic activity, a fairly safe measure of the extent of denaturation, has been used to develop methods for enzyme study. However, no information is yet available which would ascribe any functional role of a protein in acclimation. Until such a role is determined, it is unlikely that guidelines will be established by which an unaltered protein could be extracted from tissue or from a heterogenous mixture of proteins.

This discussion is inadequate to cover the problems of protein chemistry; however, it suggests that the forces of hydration in soluble plant proteins are far too small to be a significant factor in protecting cells from dehydration. It also suggests that extraction of an ultra-stable soluble protein from a freeze-resistant plant is unlikely. Although freezing survival of cells is likely limited by the stability of soluble enzymes, presently used procedures are not adequate to insure protection to the weak bond essential in protein structure.

A method used to evaluate protein denaturation has also been applied to the frost injury problem (*24*). This concept stresses the importance of sulfhydryl and disulfide bonds in protein structure. A relatively insignificant role was relegated to the hydrogen bond because of the low energy associated with it. The assumption that hydrogen bonds are unimportant provides considerable experimental convenience; however, the importance of these weak bonds in proteins has already been stressed.

A major problem in enzyme chemistry today is the lack of adequate theory to explain biological activity of proteins. One of the more recent theories is that of proton transfer (*9, 18, 26*). This concept suggests that the water bound by polar groups in proteins is not adequate to account for enzyme activity, and that a continuous layer of water on the surface molecules is necessary for proton transfer and enzyme activity. The hydrogen-bonded super-structure of water around proteins, as proposed in this theory, has some important implications. For example, it might indicate that enzyme activity could be lost *in situ* before structural alterations of proteins has occurred simply by the disruption of this water structure.

Intermediary Metabolism

ONE of the few areas in biology today where *in vitro* techniques have been successfully applied to the *in vivo* system is that of intermediary metabolism. It has been possible to account for the systematic oxidation of six carbon sugars to carbon dioxide and water and to determine sites at which cellular energy (i.e. adenosine triphosphate) is produced. The unquestionable acceptance of the

citric acid cycle in plants and animal cells is demonstrated by its discussion in most recent physiology and biochemistry textbooks. Another unique aspect of studies of intermediate metabolism is the transduction of this chemical energy to various reactions involved in growth and synthesis. The primary sites for these energy-producing and transduction systems in cells are the mitochondria. Under proper physical and chemical conditions, mitochondria can be isolated from the cytoplasm of cells for *in vitro* studies. What then are some of the experimental advantages of using these particles in the study of cell responses to environment?

(1) Mitochondria are subcellular entities having specific cytological and chemical properties which can be identified by the light and electron microscopes and by specific stains. They can be isolated by differential centrifugation.

(2) These organelles contain arrays of enzyme systems with specific chemical functions. Validity of experimental data can be determined by comparison with well-established theoretical pathways of substrate oxidation and energy transformation.

(3) Mitochondria undergo volume changes which obey osmotic laws. These changes depend upon many of the chemical reactions characteristic of mitochondria. The inter-dependence of physical and chemical reactions demonstrates an essential structural relationship.

(4) In ideal systems there is good agreement between their functional role *in vivo* and their properties *in vitro*.

(5) Deviations from ideal conditions can be traced to the isolation techniques, changes within the protoplasm of cells, or inadequate theory.

MITOCHONDRIA IN COLD ACCLIMATION

IN contrast to the present stage of development in protein chemistry, investigations on mitochondria are supported by extensive theoretical data that have been substantiated by several different experimental approaches. The intricate relationships between the physical and chemical properties of these structures impose rigid *in vitro* requirements against which further studies must be evaluated. The common effects of many metabolic inhibitors *in vivo* and in isolated mitochondria demonstrate the applicability of these *in vitro* methods to the living system. For example, the concentration of 2,4-dinitrophenol required for maximum oxygen response in extracted plant mitochondria closely approximated a similar effect in intact tissue and it also resulted in the termination of growth and salt uptake (*5*). The specific effects of certain inhibitors in blocking cell functions can be explained from a theoretical standpoint and demonstrated experimentally in mitochondria (*29*).

Besides experimentally satisfying the essential requirements of an *in vitro* system, the numerous known functions of mitochondria in living cells provide a most compelling basis for study. This is particularly true for investigations of cold acclimation and winter hardiness. Some of these functions are outlined below and suggest the need for more information as it relates to cold acclimation.

Cell Permeability and Ion Transport

VARIATION in cell permeability has often been suggested as a factor in winter hardiness. Even today, however, some workers are not certain of the existence of distinct semipermeable barriers in cells as they are now conceived (*32*). Although admitting that considerable vagueness exists on the subject (*40*), most investigators still believe that such structures are present in cells. Because of the additional evidence which will be cited and the unawareness by this writer of any better-defined diffusion barriers in cells, it will be assumed that semipermeable membranes are a distinct entity in plant cells.

The movement of water in plant tissue under freezing stress is of specific interest in winter hardiness. Water transport is still considered to be a passive process (*31*) although some calculations suggest that an active mechanism exists (*33*). The most widely accepted scheme involves the active transport of ions and metabolites against a concentration gradient and a passive flux of water. In order to understand water movement in tissue it becomes necessary to know something about solute transfer and the relationship to metabolically derived energy. The inseparable nature of ion and water transport, mitochondrial function, and membrane permeability become readily apparent.

That such an interrelationship actually exists in cells was the topic of a symposium held at Prague in 1960 (*17*). Two general theories on membrane permeability were proposed by participants of this

meeting. One group proposed the "sorption" theory of permeability. This theory states that the membrane is an inert physical barrier. The passage of ions and molecules through the membrane is regulated by metabolically controlled reactions within the cell. Proteins, for example, were visualized as selectively binding ions inside cells, thereby making them osmotically inactive. (The best argument against this theory was the report of measurement of radio-active potassium movement in squid axon. In the presence of a longitudinal electrical gradient, this ion showed nearly identical movement to that in free solution.) Their opponents proposed that the membrane is not inert and in fact is an extremely dynamic barrier whose function is regulated by the metabolic activity of the cell. Support for this theory ranged from gross observations such as pinocytosis and phagocytosis to experimental evidence of specific "ion pumps" in membranes.

Much of the accumulated information on membrane behavior has been obtained from investigations on animal tissue. Arisz (*3*) has reviewed the influx and efflux of ions in plant tissue and concluded that except for the structural difference of cells in these tissues, many of the general mechanisms of transport are common to both plant and animal. Perhaps the best supporting evidence for this conclusion is the existence of transmembrane potentials in higher plants similar to those measured in animal cells (*14*). The presence of vacuoles in mature plant cells, however, requires consideration of transport across the cytoplasm and tonoplast. A distinction has been made between the characteristics of the plasma membrane and the tonoplast regarding the transport mechanism for chloride ion in plant tissue (*20*).

Other differences between plant and animal cells do exist. Mitochondria in animal cells are intimately associated with the plasma membrane, whereas in plant cells these particles usually are in constant motion because of protoplasmic streaming (*29*). Although it is not yet understood, considerable significance is attached to the function of mitochondria in ion transport in cells. Such an assumption is fortified by experiments that demonstrate ion uptake by these subcellular structures in both animal and plant tissue.

Swelling and Contraction

HAUROWITZ (*13*) concluded that a large portion of the water in muscle tissue exists as "free" water. He suggested that this free water is mechanically immobilized by the network of cellular membranes. Support for his hypothesis has been provided by experimental results on the swelling and contraction of mitochondria in animal tissue (*21*). These data provide adequate evidence that mitochondrial swelling and contraction occurs as a result of water exchange and at the expense of metabolically produced energy. The magnitude of water uptake is indicated by the capacity of mitochondria to swell several times their normal size. Plant mitochondria exhibit these same characteristics (*25*). Similar observations on the swelling of mitochondria in plant cells have been made *in vivo* (*29*). These data provide experimental evidence that the mechanochemical behavior of mitochondria in cells influences, to a considerable extent, the distribution of water in cells. Some workers have proposed that volume changes are a consequence of hydration or dehydration of a gel system. There appears to be adequate evidence, however, to conclude that volume changes are due to the active uptake of solute by mitochondria (*39*). The data

certainly indicate the sensitivity of mitochondria to changes in osmolarity of cells or their ability to regulate such changes.

Unit Membrane Concept

THE similarities in chemical and physical properties of cell membranes have led to the theory of unit membranes. It suggests that membranes are topologically continuous, either permanently or at least during their genesis. Several lines of evidence support this hypothesis (*34*). Essential to it is the genetic origin of membranes in cells. Recently, cytological and biochemical evidence has been obtained for the existence of a repeating particle (elementary particle) in membranes of beef heart mitochondria (*10*). In the case of mitochondria there is evidence of extranuclear control (*11, 29*). This evidence is not conclusive, however, and some workers have observed an organic linkage between the nuclear envelope and mitochondria in eggs cells of fern (*6*). The presence of RNA and DNA in mitochondria and their ability to synthesize proteins has been established (*11*).

One of the implications of this concept is the use of isolated mitochondria for the study of cell membrane characteristics in response to cold acclimation. That one is, in fact, working with mitochondria can be established by an evaluation of chemical properties implicit with their structural integrity. Initial attempts have already established a relationship between chill injury and fatty acid composition of mitochondrial membranes extracted from different plant tissues (*25*). The question of the relationship between genotype and winter hardiness appears approachable through investigations on mitochondria, if it can be assumed that membrane permeability is a factor in the survival of cells under freezing stress.

PROBLEMS OF THE MITOCHONDRIAL APPROACH TO COLD ACCLIMATION

It should be stated at the onset that considerable disagreement exists over the interpretation of mitochondrial data obtained in acclimation investigations with rats. The discussion which followed a paper in a recent symposium reflects this disagreement (*7*). Since similar objections may be raised in the use of mitochondria extracted from acclimated plants, perhaps some insight can be obtained by a brief summary of that discussion. It is not implied that the mechanisms of acclimation are the same in plants and animals. The fact that mitochondria exist in both, that their fundamental function of energy synthesis is common in both types of cells, and that they are somehow affected by cold acclimation in both plants and animals—all merit some comparative thought. Cases of more specific similarities have been cited above.

Most of the argument centers around the observed increase in oxidative capacity of mitochondria from the liver of acclimated versus nonacclimated rats. These workers have demonstrated higher respiratory rates of acclimated rats and approximately doubled caloric requirement. The rate of gain was not altered by acclimation and therefore it was assumed that the increased food intake is utilized in the maintenance of the homeothermic condition during cold stress. *In vitro* data have shown a decrease in the accountable energy (ATP-measured) produced by mitochondria from acclimated compared with nonacclimated rats. The partial removal of this rate-limiting step of energy synthesis (uncoupling of ATP synthesis), by some shunt mechanism, was thought to be the cause of higher oxygen requirement of mitochondria from acclimated tissue. This shunt mechanism was visualized as providing heat at the expense of cellular energy.

The primary objection was that not all investigators have been able to confirm these results experimentally. Both groups agreed, however, that the method of mitochondrial preparation influenced the final result. Differences in oxidative rate of mitochondria from acclimated tissue were eliminated by an extensive washing procedure. An apparent dilemma existed about the choice of more washing to comply with theory or less washing to preserve the effect of acclimation on extracted mitochondria.

To find that deviations from ideal behavior occur in mitochondria preparations as a result of tissue acclimation has been disconcerting. Difficulties have arisen in determining whether inadequacies stemmed from theory or procedure. Yet distinct advantages exist for the investigation of the mitochondrial system as it relates to the acclimation process. The existing theoretical framework in this subject area, although incomplete, provides con-

stant reference points for experimentation. Recent findings have modified the once-accepted essential function of ATP in ion uptake (*37*) and have resulted in a much broader view of the functions of mitochondria (*22*). Additional stimulation comes from the continued efforts of several laboratories actively investigating the behavior of these organelles in both plants and animals.

At present there is limited experimental data available on mitochondria from plants which do acclimate to low temperatures. Apart from metabolic changes due to acclimation, it has not been possible to completely describe the behavior of mitochondria from alfalfa (*38*) and winter barley (*16*) in terms of present knowledge. The interpretation of these data has been restricted because of an inability to demonstrate ATP synthesis by mitochondria according to theory. Continued efforts have been made to comply with theoretical considerations as well as to determine differences between mitochondria of acclimated and nonacclimated winter barley.

Certain striking features of mitochondria, attributable to acclimation, have been observed in winter barley (*16*). It has been shown that the oxidative rate of mitochondria from acclimated tissue was increased by at least 50 percent over those from nonacclimated tissue. No endogenous oxygen uptake was observed in the mitochondrial suspensions of either acclimated or nonacclimated tissue. Therefore, the differential oxidation rate was supported by substrate and cofactors supplied in the reaction mixture and required by mitochondria in ideal systems. An equal stimulation of oxygen uptake was observed by adding dinitrophenol to both types of mitochondrial suspensions. The increased oxidative rate of mitochondria from acclimated tissue apparently was not due to a stimulation of ATP hydrolysis via the dinitrophenol system.

Unpublished data have also demonstrated that after one week of tissue acclimation, no difference in oxygen uptake by mitochondria was observed when compared to those of control plants. A maximum differential oxygen requirement was observed between these two sources of mitochondria after 3 weeks of acclimation. The magnitude of this differential was altered by the preparative procedure.

Recently attempts have been made to characterize the physical properties of barley mitochondria. This technique has been used primarily to improve the preparative procedure used in the isolation of mitochondria. Some of the factors responsible for swelling and contraction in ideal mitochondrial systems have also been demonstrated for barley mitochondria. Cold acclimation of barley tissue altered the swelling rates of these particles.

Regardless of the failure to presently meet the theoretical requirements of ideal systems, certain important inference can be made from these studies. These points are made in light of the fact that ATP synthesis appeared to be decreased and oxygen uptake increased in animal mitochondria, as a result of acclimation, suggesting that metabolic alterations due to this process occurred at the expense of ATP synthesis. It is also possible that acclimation of tissue has effects on mitochondria that are only indirectly involved in their function of ATP synthesis.

In view of the limited experimental data available the following alternatives are suggested to explain the higher oxidative rates of mitochondria from acclimated barley tissue: (1) Oxidation observed in barley mitochondria is due to peroxidation of unsaturated fatty acids present. Higher rates by mitochondria from acclimated tissue suggest the presence of higher levels of such acids. It has been shown that mitochondrial membranes from chilling resistant plants contain a higher content of unsaturated fatty acid (*25*). (2) Cold acclimation of tissue results in an accumulation of substances that facilitate peroxidation of existing lipids. For example ascorbic acid has been shown to increase in acclimated plant tissue. It has also been demonstrated that this compound caused swelling of mitochondria because of lipid peroxidation. (3) Oxidative metabolism is enhanced via a shunt system resulting in more rapid ion transport across cell membranes. This explanation is suggested by recent information (*37*) that ion transport is independent of ATP synthesis.

These proposed explanations on the behavior of mitochondria from acclimated tissue are similar in at least two important aspects. If any one of these explanations of the affect of tissue acclimation on mitochondria would persist, it would be impossible to show ideal behavior of these mitochondria by present standards since such oxidations do not support ATP synthesis. Their other common features is that they do describe ways in which the permeability of membranes could be altered by cold accli-

mation. Herein lies a possible paradox that can only be resolved by additional information.

Accurate interpretation of the data awaits improvement in the preparative procedure that will eliminate factors responsible for deviation from ideal behavior, and in the development of a better understanding of energy synthesis via shunt pathways. At present these alternative explanations of the differential oxidative rates of mitochondria are used primarily as working hypotheses by which extraction of these particles from barley tissue can be improved. Succinoxidase inactivation by lecithinase in barley seedling mitochondria is one problem that has been demonstrated (*12*). The development of the preparative zonal centrifuge (*1*) provides a promising new method of purifying mitochondrial preparations. Properties of mitochondria, prepared by conventional methods, are often altered by the presence of cell debris.

CONCLUSIONS

Several features of mitochondria appear to be specifically related to cold acclimation and winter hardiness. At present such associations can only be speculative. Such questions as the active or passive participation of plants in acclimation would seem solvable at these primary sites of energy synthesis. Both ion and water transport functions have also been attributed to mitochondria and have been of significant concern in winter hardiness investigations. Thus, the vague subject of membrane permeability is gradually becoming approachable through investigations of these particles. Conclusive proof for the universal application of the unit membrane concept will open several other possible uses of mitochondrial studies in the hardiness problem.

If any of the factors of cold acclimation in plants can be traced to functions inherent in mitochondria, and if present evidence on the cytoplasmic origin of these organelles is true, then the genetic incorporation of that factor into new genotypes will depend on the proper selection of the female parent. These considerations all point to a need for more extensive investigations on mitochondria and their role in cold acclimation.

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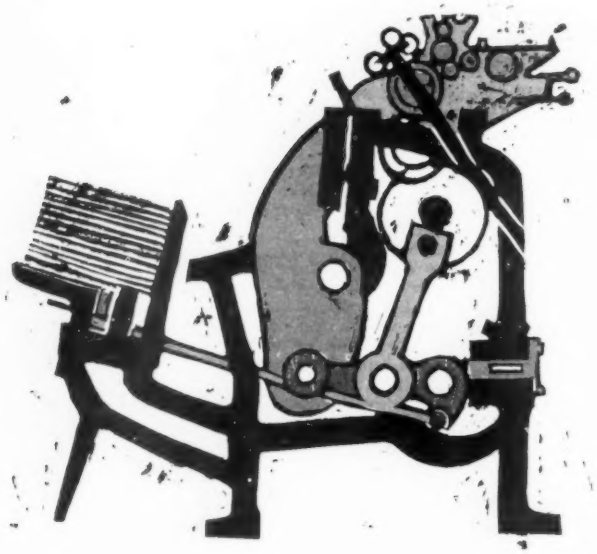
Meeting Publishing Needs in a Research Organization



A Special Report by the South African Council for Scientific Industrial Research

L. R. Dickson

THE traditional form of scientific publication, in which results are written up into papers and published in journals, had its beginning many years ago. Although a number of experts have advocated the discontinuation of this system, scientists as a whole prefer to retain it. The principal shortcoming of the system is that research workers are no longer able to read everything published in their particular fields. A situation is developing where they must decide "Which journals should I get?" and then "Which articles should I read?". According to a survey in the U.S.A., more than 9,000 journals are published in the field of chemistry alone. Abstracting journals only partly help to deal with this difficulty and there is a serious time-lag before they appear.

Problems tackled by the South African Council for Scientific and Industrial Research (CSIR) are typical of the special publishing difficulties encountered by large scientific organizations. The CSIR was inaugurated in 1946 and at present incorporates 10 national research institutes. In accordance with contemporary practice, the CSIR encourages its staff to publish their work in scientific journals and the bulk of the Council's work is published in this way. In certain cases this is not practicable, particularly where the length of the work to be published exceeds the limit imposed by journals for which it might otherwise be suited or where the project described has mainly local application.

It is, in any event, seldom possible to find space within the average article for all the data on which any particular report may be based. In the background there is invariably a much lengthier duplicated version in which the complete "story" is available. Perhaps, one day, the journals will evolve into media for announcing the existence of research reports and the sources where they may be obtained, leaving actual reproduction of the complete data to the originating authority. It seems that a great deal of paper might be saved by this means, apart from considerably speeding the acquisition of important material by those who most need it.

The library profession has developed methods that are now internationally standardized for obtaining, classifying, and retrieving material as speedily as possible. These methods are very much less effective, however, when there is no complementary effort on the part of the producer—the scientist.

In other words, format, titling, classification, standards of printing and referencing should be especially related to the librarian's requirements. Appreciating the significance of this, and of the growing dependence on libraries for the storage, retrieval, and dissemination of scientific knowledge generally, the CSIR authorities brought together in one building all activities in the field of documentation—library, publishing, and translating.

Those CSIR laboratories that had previously issued their own publications were dubious about the advantages put forward for centralization of publishing. Few of their own bulletins appeared more than once annually, however, and there was an artificial delay in publication for some papers, which had to wait until a certain minimum number of other articles were available before a complete journal could be issued. By 1958 a considerable amount of material had been issued in many different series and in a multiplicity of formats; and by then it had become clear that a more systematic approach was necessary. Libraries, in fact, found processing of these CSIR publications troublesome, and retrieving them for later enquirers unnecessarily complicated.

Careful evaluation was made of the many proposals which have been put forward since 1926 for the individual publication of articles as separates. Most of these suggestions are recorded in a report published by UNESCO in 1960.[1] The broad conclusions were that separates are desirable but that for various reasons they are not practicable. The system eventually adopted by the CSIR, basically an elaboration of the *Technical* report series published by the National Aeronautics and Space Administration of the U.S.A., is one that appears to have escaped the UNESCO study. Although each paper issued is in fact a separate, *it is published as one issue of a serial publication* (i.e. journal).

This system enables libraries to treat the papers either as separates or as serials, to be bound later in volumes in the usual way. Each separate carries its UDC number and thus is readily classified for filing under a subject heading. If unclassified separates were issued, the amount of classifying work to be done would overwhelm most libraries, thereby defeating one object of the change. In the case of existing serials previously issued by research institutes within the CSIR, identity and continuity are retained by means of different, colored overprints and titles on covers, so that libraries which have received and bound such journals in the past can continue to do so without a break in sequence.

Papers in this series, which forms the CSIR journal of applied research, are entitled *CSIR Research Reports*. Each is numbered individually, irrespective of its originating institute. Date of publication is given, but the reports are not numbered in volumes. After it has been refereed by specialists for scientific content, the manuscript of each report is sent to the central publishing office, which edits for language and CSIR house style. Suggested alterations are discussed with the author, and publishing is put in hand immediately. This avoids the delay which inevitably results from the processing necessary for conventional journals with limited text space and fixed publishing dates. Libraries that treat the reports as serials are free to bind as many numbers as they wish in one binding according to date of publication. This flexibility is particularly advantageous when reports of research may vary from 12 to 200 or more pages.

When a report contains a large number of pages, it is published as a hard-cover, cloth-bound monograph, but there is obviously no difficulty in numbering these larger separates within the overall series. Additional offprints of the dust jackets, which conform to the standard cover design for CSIR research reports, are made and these are issued as advance publisher's announcements. The contents list is printed on the inside. It is obviously impracticable for libraries to include a 200-page hard-cover book in the ordinary volume bindings. The publisher's announcements may, however, be used instead to provide reference to the book itself, which is classified and shelved in the normal way.

The bibliographic strip recommended by the International Organization for Standardization (ISO) is printed at the foot of the cover on all reports and is repeated at the bottom of the title page. Because these publications are separates it has been possible to improve the usefulness of the strip by including the universal decimal classification number within it.

This system avoids the necessity to produce off-

[1] Phelps, R. H., and Herun, J. P. Alternatives to the scientific periodical. *UNESCO Bulletin for Libraries*, March–April 1960, pp. 61–75.

CSIR Research Review
Navorsingsoorsig van die WNNR 51
South African Council for Scientific and Industrial Research
Suid-Afrikaanse Wetenskaplik en Nywerheids-navorsingsraad
Pretoria.

prints in addition to complete multiarticle journals. Close cooperation with the CSIR Library has led to a significant improvement in the standards of documentation, and by concentrating all CSIR work concerned with publishing in one division, more specialized attention to the finer points of format and printing has been made possible. Those research institutes that had misgivings about the centralization of publishing have gained in the change, for their journals appear as before, but in a more useful form and more frequently.

Preliminary analyses indicate that, in addition to a sharp decrease in publishing delay, overall printing costs have dropped. The letterpress process only has been used thus far. Experiments with electric typewriter and photo-lithographic reproduction, however, indicate that progress through the press may be speeded from the existing timetables of 4 months to as little as 3 weeks, without increase in cost.

Some critics argue that the separate lacks an important feature of the scientific journal—the place for editorial comment, letters, and discussion. This must be admitted. The view of the CSIR is that such matter more properly belongs in the review or discussion type of scientific magazine.

The Research Report series constitutes but a small part of all the CSIR's publishing work. So much had been published by 1959, in fact, in the form of reports, journals, bulletins, and brochures, that it became extremely difficult to list all that had appeared, or to locate a particular publication.

As a result of reorganization, all work is now issued within a few carefully defined categories so that it can be readily identified and traced. Publicity material, for instance, is numbered in the "B" series. Format and cover design are similar to those used for the *Research Reports,* and constitute in effect a "House Style" by which all matter emanating from the organization may be readily recognized. The same system of second color printing is used—one color for each institute—permitting further breakdown into broad subject division. Other categories cover confidential contract reports, scientific directories, proceedings of symposia, and index lists.

By these means, the CSIR has sought to simplify, to speed and control the acquisition of material published under its auspices or about its scientists' work. Those who wish to receive such literature must, however, first be made aware that it exists. Every 6 months, therefore, in *CSIR Research Review* (a journal containing reviews and abstracts which is

sent on exchange to scientific institutions, universities, and libraries all over the world) all the organization's most recent published works are listed, according to UDC subject classification, together with authors' synopses. In this list appear those reports which the organization itself has published, as well as the very much larger list of articles written by its scientists and published in other scientific journals. Readers' requests for publications or reprints are referred by the editors to the authors concerned, thereby putting workers in the same fields in direct touch with one another.

Authors often insist that tables and illustrations should appear at the exact positions where they are mentioned in the text. Where there are many, much valuable editorial time may be taken up. Text, tabular matter, and illustrations have to be juggled. Often the result is a compromise, for reference to a table is frequently made more than once in the text. To meet such cases, certain *CSIR Research Reports* are now issued in doubled format, with text, illustrations, and tabular matter in two separate book sections with a linked cover. By this means, any illustration or table may be opened out adjacent to any relevant places in the text. The text section in these reports is printed by letterpress and the illustration section (including tabular matter) by photo-lithography. This avoids the necessity for making costly blocks and simplifies tabular setting. Publishing is considerably simplified, especially in the layout stage. This format is not practicable except where papers are published as separate entities.

There is one inherent shortcoming in most current systems for the communication of scientific knowledge. Although it may be possible to inform a scientist of every development through good abstracting services, much depends on his memory. Only by using reference cards, immediately and correctly filed, can he maintain a full record of everything that is published in his field—a record that will always be up-to-date and one which will yield any required information with a minimum of searching. A few journals include classified index cards with each article. Every *CSIR Research Report* has a perforated, detachable extension of the cover consisting of two such cards, and the monthly *CSIR Library Information and Accessions* issues similarly printed entries for mounting on standard library cards, for all new books in the organization's library. All these cards are ready classified according to the UDC system.

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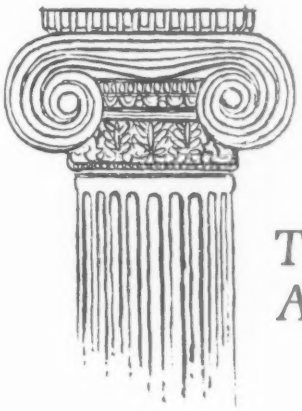

THE AUTHORS

DOROTHY DICKINS ("Research in Gerontology: Its Status and Needs") was, before her retirement earlier this year, head of the Department of Home Economics, Mississippi Agricultural Experiment Station, a position she held with honor for 39 years. She did her undergraduate work at Mississippi State College for Women, and obtained her master's degree at Columbia University and her Ph. D. at the University of Chicago in 1937. In addition to fulfilling administrative duties at the Mississippi Station, Dr. Dickins is noted for her research in family living and consumption economics.

ROBERT S. SHALLENBERGER ("Sweetening Agents in Foods") is associate professor of food science and technology, New York Agricultural Experiment Station, Geneva. He did his undergraduate work at University of Pittsburgh (B.S. '51) and his graduate study in biochemistry and plant physiology at Cornell University (M.S. '53; Ph. D. '55). He was associate technologist in chemistry for General Foods Corp. before he joined the Cornell staff

in 1956. Dr. Shallenberger's research deals primarily with the chemical reactions affecting color, flavor, and nutritive value in processed foods.

STUART PATTON ("Potentialities of the Small Interdisciplinary Laboratory") is professor of dairy science, Pennsylvania State University. He received his B.S. degree from Penn State in 1943 and both his M.S. (1947) and Ph. D. (1948) from Ohio State University. He joined the Pennsylvania staff in 1949. In 1957 Dr. Patton received the Borden award for his research achievements. He serves as consultant in dairy technology, U.S. Department of Agriculture, and is a member of the committee on food stability, National Academy of Sciences.

DONALD G. KENEFICK ("Cold Acclimation: Its Relation to Winter Hardiness in Plants") is assistant professor of agronomy, South Dakota State University. He received his B.S. degree in soils at the University of Wisconsin in 1951. After 4 years in the Air Force he began graduate studies at Michigan State University and obtained a Ph. D. in farm crops in 1959, after which he became project leader of winter hardiness research at South Dakota State University. The winter hardiness project was initiated as a result of regional research funds made available through NC 42. His research has dealt with metabolic responses of agronomic crops, specifically the influence of low temperatures on these processes.

Challenge in the Poverty and Development Programs

THE idea is coming to prevail that poverty in countries of high living standards is a social ill which can be substantially alleviated. Ambitious as this is, a major obstacle to working with the poor is the lack of an appropriate, theoretical rationale and of techniques by which new theories can be applied as they develop. As social scientists, we have had our shortcomings. At least for the past 25 years much of our research and action programing has had a middle-class orientation. We have found it much easier to work with that population and those social phenomena typical of most of our cultural backgrounds as well as of the social milieu in which we operate. Only one-fifth of the current Federal-grant supported rural sociological research in the United States has a low-income orientation. Almost none of that supported with non-Federal funds is so oriented.

Educators now are valiantly seeking ways of broadening and adapting teaching programs and methods to the needs of the underprivileged of our American culture. However, adult educational programs, when judged by their content, more often than not still are designed principally for middle-class groups. Communication media and publications tend to have a middle-class orientation, pitched to those with middle-class characteristics, including average or above-average educational attainments. Local governments and agencies very often are manned by those with middle-class values.

This cultural and operational situation frequently leads to attempts to wrench low-income individuals and families from their cultural situation rather than in capitalizing on their culture as a starting point for their rehabilitation and development and eventual entrance into the mainstream of American life. Perhaps, ways should be found to exploit the experience of our colleagues who have worked in foreign lands as one step in a better understanding of and in helping the disadvantaged to this end. The challenge now facing the discipline is an intriguing one, representing one of the best opportunities it has ever had for making a substantive contribution to knowledge regarding the effective development of the human resource factor.

PAUL J. JEHLIK
Cooperative State Research Service
U.S. Department of Agriculture

(Quoted from the author's presidential address before the Rural Sociological Society, Aug. 26, 1964, Quebec, Canada.)

The Small Interdisciplinary Laboratory

Its Potentialities in University Research

Stuart Patton

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THE whole problem of how to keep cultures, institutions, and individuals from hardening into inflexible forms that are rendered obsolescent by change has been given excellent analysis by Gardner.[1] As part of the university's effort to avoid such a fate there is increasing discussion and action about so-called interdisciplinary programs.

In the particular setting, interdisciplinary is broadly held to mean any realigning or combining of resources to meet new needs. At the intellectual level the idea is probably at least as old as the proverbial "two heads are better than one." But broad-scale consideration of an interdisciplinary approach to research at the university is a relatively recent phenomenon. A fine early example of this approach concerns the organization of researchers in the 1940's at the University of Minnesota to study the effects of diet on human well-being.[2] For meaningful long range results on this problem, talents and training from many disciplines were required—nutrition, biochemistry, physiology, psychology, medicine, and others.

[1] Gardner, John W., 1963. *Self-Renewal. The Individual and the Innovative Society.* New York, Harper and Rowe.

[2] Brozek, Joseph, 1963. *Experimental Investigations on Nutrition and Human Behavior: A Post-Script.* American Scientist 51: 139–163.

The crux of the matter is that there are many important problems, both basic and applied, which the traditional university resources of a professor working with a few graduate students simply cannot hope to solve. As science digs deeper into fundamental phenomena, its knowledge and its tools become increasingly complex and tend to exhaust individual competence. As an example of such a problem let us consider fat metabolism in the bovine—a matter of considerable practical importance since the animal supplies meat fat and milk fat to the human diet. If we wish to know how these fats are made in the animal and thus why they are the way they are (e.g., saturated or unsaturated), we will have a multi-man-sized problem. We will need specialists in the bovine (meat and milk), biochemists capable in the fields of lipids and enzymes, a microbiologist (for rumen work), a physiologist, a cytologyst, a veterinarian, as well as technique specialists in organ perfusion, radioisotopes applications, spectrophotometry, chromatography, and miscroscopy. Interdisciplinary problems of this type, at both basic and applied levels, are important and commonplace today. And although the manpower needs in the foregoing problem may sound overdone, they are only so to the extent that some talented people can have reasonably good mastery of more than one specialty. However, the forces at work are reducing the number and effectiveness of such people.

Science on the Head of a Pin

The fast pace of science and technology is one of the most unsettling intellectual concerns of our times. Writers and orators hammer away at impressive statistics on the expanding number of people engaged in research and development; on the exponential increase in numbers of scientific papers, journals and books; on the problem of recovering information once it has disappeared into the heap. They admonish us that the future will belong to those who can live with change. But it is not quite clear how we are to do this. The teacher wonders what out of the swelling mass of knowledge should be taught. Even more disconcerting, he wonders how to locate and keep up with rapidly expanding information in his particular area.

The problem for the researcher also is very serious. Originality is the crux of research and one is never sure in these times whether things are being discovered or simply rediscovered. Enlightened research presumably starts from the base of a thorough literature search. Since this is a difficult ideal the practical possibility opens out in two directions. The area of competence can be narrowed (specialized) to a point where literature competence can be maintained at least for a time. Or the literature can be considered more casually and one can discover what he wishes to in his own little world. The first of these alternatives raises the question: How likely is one to discover anything of broad significance as he narrows his intellectual preview? The second leads toward literature chaos and problems in proper crediting of scientific discovery.

Finally, the issue becomes really serious if one hopes or is expected to both teach and research with distinction. Obviously it is increasingly difficult to do either. That classic type professor who instructs while he pushes back the frontier of knowledge will become a rare bird indeed.

Evaluation at Penn State

The Research and Graduate Study Committee of the College of Agriculture at Penn State has the responsibility of evaluating the quality of the research program and prescribing change where it seems needed. In recent years the Committee spent much time discussing the problem of conducting research in such a dynamic scientific era. Much attention was given to the possibility of a research institute. The thinking was that a pure research environment for at least some of the faculty would deliver them from the problem of what should have priority among the many duties and functions of the average departmental staff member. It was also felt that a research institute would help to maintain quantity and quality of research at least in its area of designated responsibility.

The Committee also thought that the research institute had some distinct limitations. As an independent unit, it would be difficult to establish on a modest scale; thus, its development and funding would be a major undertaking. Concern was also expressed about the removal of skilled research faculty and equipment from departments to an institute. The question was raised: What would be left at the departmental level after such a change? There also seemed to be a strong feeling, not only

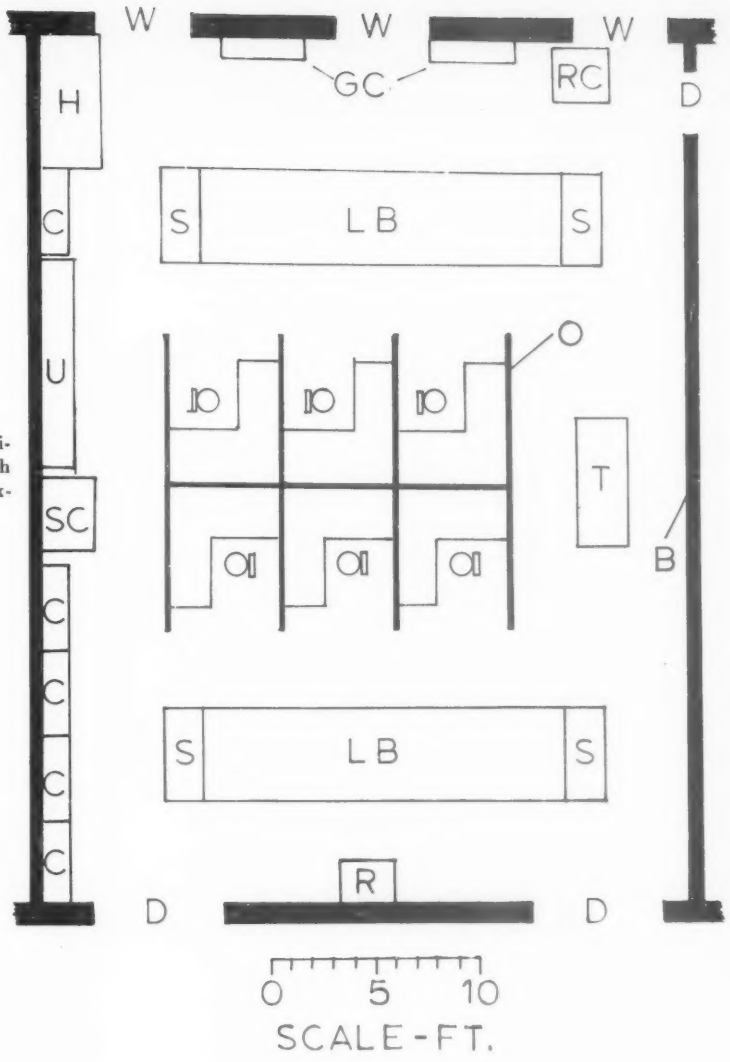


FIGURE 1. Scheme of the interdisciplinary laboratory for lipids research at the Pennsylvania Agricultural Experiment Station.
B—Blackboard
C—Storage Cabinet
D—Door
H—Fume Hood
O—Officettes (6)
R—Refrigerator
S—Sink
T—Seminar Table and Chairs
U—Utility Table (Weighing, etc.)
W—Window
GC—Gas Chromatograph
LB—Lab Bench
RC—Refrigerated Centrifuge
SC—Scintillation Counter

within the Committee but with many of the faculty, that it is beneficial for research people to teach at least in the area of their research interests and that people who find this an unpleasant obligation ought not to be connected with universities in any capacity, research institute or otherwise.

Of course, the question to have or have not a research institute raises many issues and develops emotional partisans on both sides. This problem along with many others on the general subject of research was aired before the faculty of the College of Agriculture in a series of seminars held during the first half of 1963. Although these seminars left many of the issues up in the air, it was established that there are contemporary problems in how to conduct research and that one of these is how to provide better research environments for the college professor. One effect of these seminars and the Committee studies was a suggestion for something smaller than a research institute which could be integrated at the departmental level. In a rough way this described a small interdisciplinary labora-

tory and the Committee turned its efforts towards development of such a unit.

Development and Operation of the Interdisciplinary Laboratory

It was decided that lipids, a field of intense current interest, would be an appropriate area of responsibility for this first laboratory. The subject is fundamentally important to agriculture and to programs of many of the departments within several of the colleges at Penn State. Another formative situation was that space for the laboratory would be available within facilities of the Department of Dairy Science and that a core project from that department on synthesis of milk fat also would contribute to the plan. This project is supported by funds from the Public Health Service and the Agricultural Experiment Station. Money from these two sources together with accrued income from sales operations of the Department of Dairy Science enabled the design, construction and operation of the new laboratory (fig. 1). The cost to convert the empty room, including new floor, refinishing of walls and ceiling, new lights and extension of utilities, all furniture, instruments, glassware, and supplies was about $35,000.

The laboratory is organized and operated quite informally. Although the head of the Department of Dairy Science is administratively responsible for the unit, no formal titles for personnel are used. A committee of 9 or 10 members, derived from departments of the university having interests in the field of lipids, serves as a means of directing interested parties to the new facility. Anyone who works in the laboratory is expected to assume some responsibility for its maintenance and operation. Since faculty move in and out of the laboratory, depending upon available time and other obligations, continuity in planning and the maintenance of supplies and materials is taken care of by a full-time research assistant.

The laboratory is mainly designed to handle lipids analysis by gas, thin-layer and liquid column chromatographic techniques. This is further supported by scintillation counting equipment, enabling study of lipid metabolism with the aid of radioisotopes. The idea has been to make the facility available to anyone who might profit from using it. The small office units were included in the design so that visiting scientists or professors from other departments with inadequate space would have a place for desk work and storage of data. The Department of Dairy Science proposed to assume all expenses within reason and has done so to date.

In addition to use by resident professors and visiting scientists from other universities, the laboratory has been used by graduate students from various departments, by high school students during summer science programs, and by scientists from government and industry. A common practice has been for technicians to come and learn techniques so that these could then be used on projects in their home departments.

Merits and Limitations

After a year and a half of operation, the laboratory has proved to be at least a qualified success. Faculty, particularly within the Department of Dairy Science, have been able to move back and forth between research activity in the laboratory and their many outside obligations. There has been no need to drop everything in the way of research while a term is devoted to teaching. Technical assistance and operating instruments continue to be available and collection of data on planned phases of work can still go forward. At the very least, if a staff member did need to stop completely for teaching and other commitments, he could come back at any time to an on-going operation with facilities and instruments in working order. Although no record has been kept of the number of people served, there have been as many as twelve people (probably this should represent an upper limit) working in the laboratory at one time. The general idea of the laboratory seems to be stimulating and has tended to bring people of interesting but diverse concerns in the fields of lipids together. Analyses of lipids from milk, meat, eggs, feed materials, insects, spermatozoa (various species), groundhogs, bacteria, cell cultures, intestinal contents, among others have been carried out.

The laboratory has also helped to solve the problem of distribution and use of large and expensive instrumentation. Some colleges have solved this problem by forming central analytical laboratories [3]

[3] Luckey, Thomas D., Gehrke, Charles W., and McDermott, Robert E. 1960. *Strengthening University Research*. American Scientist 48: 216A, 220A, 224A, 228A, 232A, 236A.

where all such instrumentation is kept and used. Others have felt that such instruments might be more accessible for use if they are placed in the most appropriate departments. Although again there are many partisans for both sides of this issue, a small interdisciplinary laboratory becomes a very logical place to put the expensive instrumentation needed to cover its particular field.

In addition to good ideas and operating principles, the effectiveness of any organized unit will depend upon the personalities involved. In this particular instance the working relationships have been not only smooth but stimulating in the opinion of those mainly concerned.

The laboratory also has defects. Most of these have been relatively minor, such as a flooring composition that is attacked by the organic solvents used in lipids work. In addition the seminar table arrangement is rather useless because of the high noise level usually prevailing in the laboratory. This space probably would have been better devoted to additional office area or perhaps it will be well to reserve it for future instrument space.

It may be a major defect that resident faculty from departments other than Dairy Science have not tended to participate directly in use of the laboratory. The tendency has been for them to send technicians and graduate students to learn techniques or to bring back data. These faculty members have sought and lent themselves in consultations regarding lipids problems, but they, themselves, have worked very little in the laboratory. This may not be undesirable or even unexpected. It may simply reflect how little time the average professor has for direct participation in laboratory work. However, it is the author's contention that the entire academic tradition of assigning faculty members to particular and fixed departments, buildings, and budgets tends to rob them of their flexibility in research.

Outlook for the Future

One question logically raised concerns the fate of this new laboratory. Depending upon aspirations of personnel involved, it could remain most useful at its present size and scope, or it might be viewed as a staging ground toward a much larger operation, eventually even a research institute. The function and direction of the laboratory may change as its key people and their interests change. It is notable that the laboratory is of such a size and flexible commitment that it could be easily reorganized for other purposes. Basically the laboratory is quite conventional except for some equipment and instruments such as gas chromatographs and a scintillation counter, that have more limited applications. But even these are not exclusively of service just to the field of lipids. The thinking of those connected with the Lipids Laboratory is that more units of its type should be developed at Penn State. Presently under consideration is an interdisciplinary laboratory for protein research and another for agricultural chemicals investigations.

It is essential that the university maintain a search for new and improved research environments that will help to keep the university's teaching and research efforts alive and vigorous. From the standpoint of providing facilities and technical assistance in attacking lipids problems, the interdisciplinary laboratory described here has been highly useful to scientists of quite diverse interests and training. Such environments of collaboration and assistance seem almost mandatory for the future. While it must be admitted that a new idea takes root initially in an individual mind, the working out of the truth in science has always been a collaborative effort—that is, building on or from the information that others have supplied. In addition to this help from the past, the trend suggests that the researcher will increasingly need help in the present—the help of his co-workers.

In the preceding paper, Dr. Patton presents one approach to the problem of improving the research environment at the university level. Whether his idea merits consideration under different settings will remain a matter for individual departments and disciplines to decide for themselves. Because of the importance of the topic, *Review* will be glad to consider other manuscript contributions about outstanding examples of interdisciplinary cooperation. Address your report to the Editor, *Agricultural Science Review*.

Community-Family-Consumer Research

A Report of a Critical Study

IN June 1963, Dr. T. C. Byerly, Administrator of the Cooperative State Research Service, U.S. Department of Agriculture, appointed a work group [1] under the chairmanship of M. E. John, Pennsylvania State University, to review the research conducted by the land-grant institutions in the areas of the community, the family, and the consumer.

The work group was asked to consider: (1) Research recently concluded or currently underway, (2) quality of research as revealed by publications and research design, (3) kind of research needed, and (4) obstacles to research development. In addition, the work group was asked to develop goals and guidelines for future program direction.

Research in the technological aspects of food and textiles and studies in basic human nutrition were intentionally omitted by the work group, because such programs were considered to be only indirectly related to community-family-consumer research. The boundaries of this report have no known parallel. Essentially the report deals with the social and material well-being of individuals and families, including their behavior and interests as consumers. It encompasses their decision-making, their endeavors to attain goals, and their relationship to the community. *Review* presents here the full and final report of this work group.

* * *

THE United States has achieved production in abundance, and at the same time many of its people have more free time than citizens of other nations. This accomplishment serves to underscore the ever present question, "Are we, as a Nation, using our abundance in a way that contributes most to quality of living?"

Our ability to live and work with one another, to use our income and other resources wisely, and to solve our social problems has not advanced as rapidly as our ability to produce materially. Yet, presumably, the ultimate objective of all production is for human betterment.

In spite of our advancement in skills and technical knowledge, the levels of living of many people and the public services and facilities of many communities are below those widely accepted as normative in American society.

We now urgently need information to guide individuals and families in decisions that will contribute to their development and to the utilization of material resources so that the long-range well-being of individuals, families, and society will be enhanced.

Research directed along these lines will concern itself with people and their quality of living. Attention will be focused on the family or the individual in its social and cultural milieu, and on the processes whereby resources are allocated to obtain the goods, services, and experiences desired.

The ultimate goal is to discover the method whereby people can maximize their satisfaction and well-being through both public and private means. Assisting people to achieve this goal requires an understanding of the factors affecting behavior and the consequences of decisions in terms of both the individual's desires and the welfare of society. Research can contribute needed insights.

THE FAMILY

NO unit in society has as significant an impact on the next generation as the family. It vitally influences the relationship of individuals to the community and the larger society. The family is paramount in determining the behavior, basic beliefs, values, and aspirations of people, and in setting the pattern for development of youth.

[1] Names of the members of the work group appear on p. 52.

American families exemplify widely differing patterns in living. In general, middle class values and goals have been dominant in society's expectations for others, and these same overtones are strongly reflected in research undertakings. This single-class approach is not meaningful in terms of understanding today's problems and the needs of all families.

In an increasingly complex society, the family is only insignificantly identified as a unit for production of the goods and services it enjoys. The well-being of the family depends upon the adequacy of its resources, the wisdom with which resources are used, the adequacy of community offerings and the use made thereof, and finally upon the economic and social systems as they provide for human needs. Since the family serves as the final decision-making unit through which foods, services, and experiences are channelled for ultimate use, family decisions are fundamental to the well-being of all.

Evaluation of Research

HATCH funds administered through the State agricultural experiment stations have been used to study the material aspects of the home, but almost none of the research has been directly concerned with the family. Presently, that research which does have bearing upon family living is being undertaken by family economists. Some family research has been done with State funds or grants from foundations or Federal agencies.

Much of the non-Hatch research has focused on human growth and development, primarily the physical and social processes whereby the individual

moves through life's stages. Most attention has been given to the preschool child. Nursery schools as a facility of colleges, schools, and departments of home economics have served as convenient laboratories for these studies. Research concerned with the aspirations of youth has been undertaken by rural and family sociologists.

Another area receiving attention but funded from non-Hatch sources has been courtship and marriage. The campus has provided an opportunity to study factors associated with mate selection in a limited socio-economic segment of society. Little attention has been given to the lower and upper segments of the populations or to those with other than Western European backgrounds. Studies of adjustment in marriage have grown out of university and public counseling services.

Limited but very useful research concerned with level of living of families has been conducted by agricultural or family economists and rural sociologists. Family economists have made some studies relating to family expenditures and family financial management, but few in recent years. The findings from these types of research provide insights helpful in farm and home planning and in analyzing financial needs of rural families under economic stress. Public agencies find this type of information of value.

Needed Research

1. DISADVANTAGED FAMILIES—Low income and deprived social backgrounds create a social environment that tends to be self-perpetuating.

The following research questions have relevance:

a. What are the expectations that nondisadvantaged families have of the family in poverty? To what extent are low-income families aware of the image of expectation held by others? To what extent is the image preventing or helping the disadvantaged family in improving its lot?

b. By what process have some young people from low-income families risen above their backgrounds and reached the middle- or high-class levels? To what extent can the forces significant to this rise be introduced through improved planning?

2. FAMILIES IN THE RURAL-URBAN FRINGE—Improvements in transportation have helped encourage many families to try to obtain the best of two worlds, urban and rural. The fringe brings together individuals with diverse backgrounds and different loyalties. From such a social setting the following questions arise:

a. What effect does life in the fringe have on family solidarity and stability?

b. What effect does it have on relationships between families, and on their sense of "commitment" to the community?

c. What effect does it have on the socialization of the young, on juvenile delinquency, on early marriage, and on educational aspiration?

3. IMPACT OF TECHNOLOGY ON THE FAMILY—Rapid social change creates situations of stress for families. These research questions have relevance:

a. What effect do changing occupational demands with requirements for more specialized and technical training have on the family?
b. How does increased mobility, with its concomitant strain, affect the family and its community ties?
c. What is the effect of married women working away from home on the family members and on the community?
d. What is the impact of leisure time on patterns of living and demand for community facilities?
e. What problems arise as a result of retirement of individuals in good health and with many years of life remaining?
f. What adjustment problems arise when aged persons lose their spouse?
g. What is the impact on families when functions are shifted from the family to other institutions?

Obstacles

- One of the major obstacles to more and improved research in this area is the shortage of personnel whose training integrates psychology, economics, and sociology.

- Lack of support has limited use of available methodology on larger and more diversified population samples, as well as hindered the further development and refinement of methodology.

COMMUNITY PROGRAMS AND SERVICES

As our level of living has increased, so also has the interdependence of people in their effort to satisfy human needs. The demand for community programs, services, and facilities provided through both governmental and private action has expanded, and the kinds of programs desired have broadened. Strong complementary research programs could facilitate the planning of programs and services to meet the needs of special population groups, such as the aging, families with low income, and occupational groups disadvantaged through technological change.

It is important that decisions pertaining to community interests reflect the desires and needs of the people, and that services be effective and efficient. We need better understanding of the pertinent functions of the individual, of private agencies, and of government, as well as insight regarding community decision-making.

Evaluation of Research

Almost no research has been undertaken that yields understanding of family desires and uses of community programs and services. This is especially true of programs that most closely supplement, and at times take over, family functions and responsibilities. Evaluation of long-range effect of programs has been largely a matter of observation rather than study.

Research concerning the nature and functioning of rural communities is not new, but only recently has much attention been given to the community decision-making process and its relationship to realized community improvement. Although interest in community action is now high and some research has been undertaken, greater insight is required before the full impact of a research contribution is realized.

Needed Research

1. IMPACT UPON THE FAMILY AND EFFECTIVENESS OF PUBLIC AND PRIVATE COMMUNITY PROGRAMS AND SERVICES—The following questions need answering:

a. Are family-oriented programs and services too standardized to meet the needs of widely differing segments of the population?
b. What degree of centralization in planning is most desirable in programing for attack on various kinds of local needs and problems?
c. To what extent do programs for providing services through the community social systems reflect bias?
d. How effective are the various governmental programs designed to improve level of living?
e. What impact do present programs have on the motivational level of low-income families? Does aid facilitate or hinder longtime recovery?

2. COMMUNITY PROGRAMS AND SERVICES DESIRED BY FAMILIES—

a. What kind of community services do fami-

lies in various categories desire? What are the reasons for lack of availability of desired services?

b. What is the proper balance between private and public spending to provide desired programs while at the same time achieving a consistent position relative to the values of people in different categories?

3. UTILIZATION OF PUBLIC SERVICES—

a. What is the level of utilization of services by families in various segments of the population? What are the obstacles to further use?

b. How adequate are present services in light of the broad norms established by society?

4. COMMUNITY DECISION-MAKING—

a. How are various kinds of community decisions made regarding provisions for programs, services, and facilities?

b. What understandings about government, private agencies, and the family would facilitate the development and implementation of community action programs?

c. To what extent does the decision-making process consider the needs of all classes of individuals and families?

Obstacles

- This research requires the academic skills of the economist, sociologist, and political scientist, among others. Each discipline can make important contributions working alone, but a team approach is required for some of the problems. Essential interdisciplinary cooperation is difficult to achieve.
- The lack of appropriate methodology serves to handicap research on some problems; community decision-making is a case in point.
- There is some administrative hesitancy in encouraging qualified and creative research talent to move into the difficult, untried areas of community research.

THE CONSUMER

CONSUMER research deals with the decisions of families in the allocation of resources to obtain goods, services, and experiences. It includes (1) comparative values placed on different goods and services as revealed by consumption patterns, (2) the underlying meaning or significance attributed to goods, services, or experiences, and (3) the analysis of the formulation of wants, means of fulfilling these wants, and of the decision-making process used in selecting between available alternatives. This area is also concerned with the research basis for consumer education programs.

Evaluation of Research

CONSUMER research by the State agricultural experiment stations has been scanty. More comprehensive studies are needed to provide a better understanding of the way people in various income classes with different backgrounds and under diverse social and economic conditions allocate their resources.

Consumer decision-making within the family setting has been the subject of few studies, and our knowledge and methodology in this field is not commensurate with its importance. Too many of these studies have dealt with rural people. Yet families in all segments of society face new kinds of problems growing out of the rapid changes in living conditions, in incomes, in goods and services available, in the volume and kinds of information available, and in the pressures exerted upon the decision-making process. We need more fundamental understandings about the interrelationships among expenditure items, the market climate which consumers face, and their preferences in that climate. The decisions that families reach on consumption and how effectively their preferences "feed back" into production decisions will largely determine the directions of changes and developments in our living patterns and the uses we make of our capacity for abundance.

Food consumption patterns have been studied through national surveys conducted by the Consumer and Food Economics Division, Agricultural Research Service, and through analysis of data from metropolitan consumer panels and regional or State samples collected by station scientists. All have contributed valuable information over time, but they have been limited to one expenditure item—food. They have contributed little to the development of a workable theory of consumption. Industry has used these data for market analysis, and the dietary analysis has provided at the regional and national levels a gross picture of nutritive content of foods consumed. Studies of this

type must be made with some frequency if data are to be used for these purposes.

Expenditure studies indicating the more complete range of consumer decisions and the competitive positions which items hold, one to the other, have been made by Federal agencies and by a limited number of commercial interests. Samples for the Federal studies are drawn to reflect the national, regional, and metropolitan areas only. Very few studies of this type have been made at a State level. Moreover, although data from both the national food consumption and family expenditure studies are available, little use has been made of these data by station workers.

Consumer food preferences have been the subject of numerous station studies, but these have chiefly involved specific quality characteristics of single commodities. They have been of immediate practical value to industry in guiding product development and merchandising efforts. Only a few such studies have explored the "why's" behind the preferences, and these usually met with limited success because of the methods used. The significant consumer attitudes often are submerged in emotional meanings which cannot be tapped by direct questioning. The person himself is not consciously aware of the underlying reasons. As a result, few general principles have been developed that further our understanding of consumer preference patterns.

The real shortcoming in this research to date is that it is highly applied. Studies do not "build" in terms of either a basic or applied interest. The work is developed almost entirely around food, and is highly oriented toward an industry interest without a counter-balancing effort in the consumer's interest. This latter is needed as a basis for consumer education programs. Several of these shortcomings reflect characteristics common to any developing field of research. However, the paucity of consumer research which leads to generalizations and principles makes it difficult to assist families in the effective utilization of resources to achieve a high quality of living.

Needed Research

1. What are the consequences of consumer decisions on the quality of living of individuals and families?

2. How effective are the communication channels from consumer to producer in indicating various types of wants? Are the mass marketing practices allowing for reflection of differences in consumer preferences?

3. How do information sources influence various types of consumer decisions? What are the differences found among different population strata? What are the information needs of the different strata?

4. What effect do living patterns, stage of life cycle, values, goals, interests, and attitudes have upon choice-making and consumption patterns?

5. Can behavior theories from psychology, sociology, and economics be integrated and made useful in the development of a workable theory of consumption?

6. How do consumers allocate their resources among available alternatives? What are the factors influencing their choice?

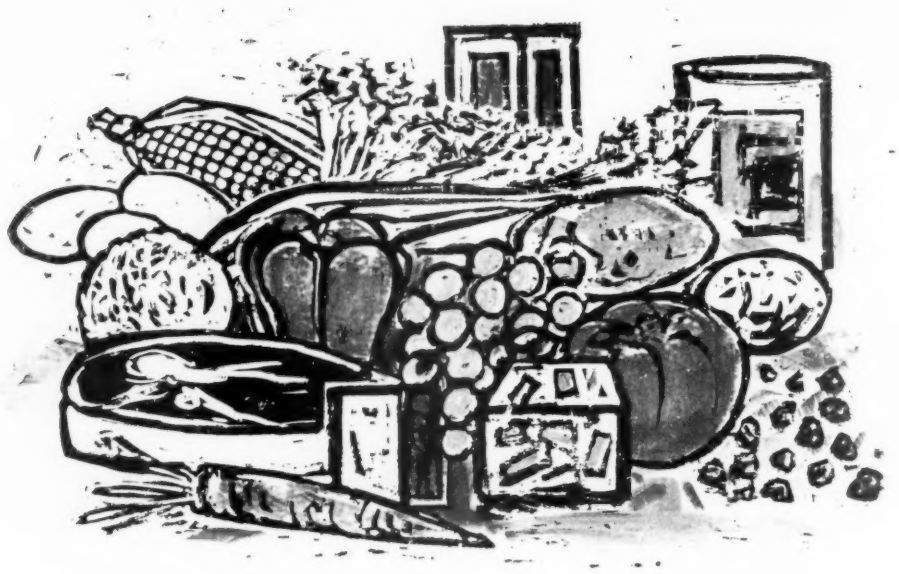
7. What is the impact on consumers of various market structures and practices—packaging, legislation, quality standardization, trading stamps, and credit policies?

Obstacles

- One of the major obstacles is the shortage of personnel interested in the theoretical aspect of consumption. There are few consumption economists on experiment station staffs. Likewise, few social psychologists well-grounded in methodology have been drawn into this area of research. Well-trained workers are essential to undertake basic research that investigates the "why's" of human behavior.
- There has been a tendency for inadequate support of fundamental research in this area. Available funds have been used to finance applied studies of interest to commodity groups. Closer coordination and cooperation of qualified personnel from various parts of the university are needed.

FOOD

VARIOUS factors operate concomitantly in the selection of food. A wholesome food supply that provides the nutrients required for growth and body maintenance is essential to health and contributes to physical well-being. For many individuals, however, wholesomeness and nutritive value may be less significant in determining food choice than are



sensory appeals or various social, cultural, psychological, and economic factors. The provision of food in the family-consumer context usually accounts for a significant expenditure of income and time, and therefore directly influences the quality of living.

Evaluation of Research

CONSIDERABLE research has been conducted in the area of human nutrition and food science. Emphasis has been placed on developing an understanding of the human requirement for various nutrients and on the utilization of nutrients from usual food sources. Many studies have been made of food preparation and preservation as they affect quality, cost, and time expenditures by both families and institutions. Studies have provided information concerning the use of food to obtain nutritional, sensory, and other satisfactions important to consumers. To the extent that research findings first influence food producers and the food industry, so do they affect the quality and types of products available to consumers. Moreover, this knowledge can be used to develop guides to consumers in making decisions concerning food choices, and to assist them in achieving physiological and psychological satisfactions from food.

Because of the many new foods on the market, continuing research designed to determine the nutritional and other contributions of these foods is essential. The U.S. Department of Agriculture and the agricultural experiment stations are the major public agencies undertaking this work. These agencies should continue their research leadership in this area and increase its pace in accordance with market changes.

Extensive research has been directed toward a study of eating patterns. Research dealing with food habits—and to those factors that explain why people eat as they do—has been very limited. A considerable gap still exists between what is known about nutrition and the degree to which many people understand and apply this knowledge in their food practices. Certainly, for many families, what is nutritionally desirable is not the sole basis for the choice of food. Nor are the advantages of an adequate diet a strong motivating force in food selection.

Needed Research

RESEARCH in food science and nutrition needs to be expanded to include studies of the psychosociological significance of food and of factors influencing family decisions in food selection. The following questions need answers:

1. What factors operate in consumer choices of food?

2. How are food habits formed?

3. What are common misconceptions about food and nutritional needs? What is their effect on dietary habits?

4. What are desirable food habits and attitudes? How can they be established and undesirable ones effectively modified?

5. What meaning does food have in the American culture? How does social significance of food vary among segments of the population?

Obstacles

- Problems relating to the psycho-sociological aspects of the food and nutrition sciences require an interdisciplinary approach. Research scholars presently in these areas come largely from a biochemistry background. To attack the kinds of problems listed above, personnel with psychological, anthropological, and sociological capabilities are needed, along with the physical scientists.
- Qualified social scientists have not been particularly interested in food habit studies.

CLOTHING

CLOTHING contributes to the individual's concept of self and aids in creating a sense of appropriateness in social situations. The "fitness" of clothing is especially important for economically or socially deprived individuals. Hence, clothing has sociological, psychological, and economic implications, as well as physcial.

Clothing consumers find decision-making more complex today than in the past, largely because of diverse market offerings and problems in prejudging items available. The multitude of fabrics, the wide number of generic names given to fibers, and the amount and complexity of present day advertising—all contribute to the consumer's problems. Additionally, situations are more differentiated in terms of what is appropriate in clothing. The consumer's need for knowledge relevant to the constant changing products and situations cannot be underestimated.

Evaluation of Research

A LARGE part of the clothing research has focused on the physical attributes of fabrics as they are related to the fiber and fabric performance. Such work contributes to the well-being of consumers insofar as these results affect the nature of the product offered and are used as guides in choosing and using consumer textiles. Stated objectives for this type of research ordinarily have not considered consumer preferences in relation to differences in income, age, or social situation.

More recently, studies have included the effect of varied social variables, such as group participation and occupation, on clothing needs and preferences. Attention has also been given to the needs of specific groups, such as older women and the handicapped. Recently, attempts have been made to discover the relationship between characteristics of fabric and garments and the satisfaction of consumers. Such information should assist the industry in new product development.

For the most part, research on the social, psychological, and economic variables is in its infancy. Attention, of necessity, has been given to the development of methodology and to acquiring skill in interdisciplinary approaches. As a result, there is a solid research foundation on which to build more extensive and statistically sound studies. With the diversity of alternatives in clothing, additional knowledge is needed on the basis and consequence of decisions to assist the consumer in maximizing his satisfaction.

Needed Research

THE following kinds of questions need to be answered through research:

1. What symbolic meaning does clothing have as related to economic and cultural values?

2. What characteristics and qualities in clothing contribute to consumer satisfaction in use?

3. How do such factors as fashion trends, body conformation, age, sex, and social class affect clothing preferences and selection?

Obstacles

- Only a small number of personnel are well-trained in social science research techniques. Moreover, they are insufficiently interested in the application of these techniques to clothing problems.
- In some land-grant universities and within the regional organizations, inadequate liaison between

research in the physical and social science prevents integration of effort.

- Social scientists working in clothing research usually prefer work in their basic discipline. The combined training in one individual should be encouraged.

HOUSING

SHELTER encompasses all the physical environment within which people live—the house indoors and out, the neighborhood, and the community. Living occurs against the background of these settings. The quality of life is in part determined by the influences of the physical surroundings on actions and attitudes.

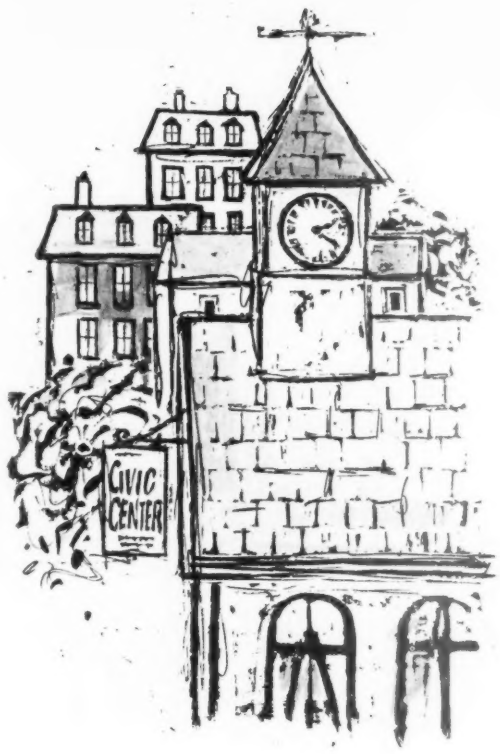
Housing research focuses on understanding these relationships so that improvements in the physical environment can be made. Research results are directed toward two groups: (1) The housing industry to encourage the establishment of standards and criteria for houses and neighborhood developments planned to meet consumer needs, and (2) consumers through educational programs so they can choose more intelligently among the alternatives available.

Evaluation of Research

MOST of the housing work sponsored by the U.S. Department of Agriculture and the State agricultural experiment stations has been undertaken by agricultural engineers and home management researchers. It has reflected the interests and competence of these groups, including: Needs and preferences for the location of activities in farm houses, space requirements for activities and storage, design of functional arrangements of space, efficiency and energy studies of component activities, and studies of the thermal and visual environment, structures, materials, mechanical equipment, utilities, and of certain safety aspects of the house. Recently, an extensive project was undertaken in housing for the aged.

Completed studies on the physiological aspects of energy expenditures have yielded valuable information and appear to provide sufficient data for present purposes.

Space requirement work should be redirected and expanded into more comprehensive studies of patterns of living to provide data for rational design.



Needed Research

THE following kinds of questions need to be answered through research:

1. What is the effect on individuals and families of living in multiple-unit dwellings; tracts of identical houses; mobile homes; neighborhoods of similar people, such as communities for the aging, public housing areas, or migrant labor housing; and institutions, such as nursing or juvenile homes?

2. What are the impacts of single-class neighborhoods on the socialization of children?

3. What is the effect of social, economic, cultural, and racial integration in housing on social patterns?

4. What is man's need for privacy? How much? What kind? What is the effect of too much or not enough privacy? Can privacy needs be stated in terms of minimum and optimum standards?

5. What are man's esthetic needs in housing? How do these differ for various population groups?

6. Can low-cost and low-maintenance flexibility in house design be achieved?

7. At what point do variations in family living patterns—reflecting different stages in the life cycle, locality, economic stratification, or social differences—become pertinent in the development of functional housing and the consideration of space needs for families?

Obstacles

- The interdisciplinary character of the housing problem has impeded development of a professional group to encompass the field. The difficulty of compiling information is formidable. Lack of institutionalized methods of communication will continue to impede progress.
- Although experience in other parts of the world, especially in Europe, would be valuable as we move through similar urbanization processes, pertinent reports cannot be used because they have not been translated.
- The scattering of professional people interested in housing is illustrated by the number of agencies involved. Within the U.S. Department of Agriculture, for example, Farmers Home Administration, Federal Extension Service, Agricultural Research Service, and Cooperative State Research Service all have housing interests. Other agencies and interested groups include Housing and Home Finance Agency, Veterans Administration, American Institute of Architects, National Association of Home Builders, and Building Research Institute. This proliferation further impedes the coordination of research and communication of results.

CONCLUSIONS AND RECOMMENDATIONS

Few fields of research are as full of promise as the complex areas of community, family, and consumer studies. Understanding the individual and his family is of prime importance if human well-being is to be advanced. Accelerated social and technological change is forcing us to be more keenly aware of human needs.

Today man must be more than a reactor to change; he must be in a position to influence change. Research is an important tool in this effort.

The research areas covered by this report provide understandings that will (1) assist families in making wise decisions in the use of all available resources, and (2) assist producers, processors, and distributors of goods and providers of services to understand consumer needs and preference. More high quality research seems imperative if society intends to use its productive capacity to maximize its contribution to the general welfare. There is continued need for consumer and family-oriented studies that provide basic information about food, clothing and shelter. At the same time a greatly expanded research program needs to focus on the consumer as a decision-maker and on his consumption patterns. Only research can provide information on the effects of various social and technological changes on families, their way of life, and their needs and preferences.

Probably the greatest obstacle to the realization of a research program of the desired level, both quantitative and qualitative, is the limited number of highly qualified personnel and the small portion of their time being devoted to research and graduate education. All organizational possibilities should be exercised to provide for the rapid development of needed research talent. This should include: (1) More financial assistance for the training of graduate students, (2) increased opportunities for aligning inexperienced research personnel with strong research leadership through regional programs, (3) more junior positions related to on-going research projects, (4) adequate opportunity for professional growth of research personnel, and (5) increased support for projects in terms of technical personnel, facilities, and operating budgets.

Every effort should be made to draw upon the supporting disciplines to maximize the use of scarce personnel and to assure the competence and quality in experimental design and research methodology. This is most essential in the social sciences since, in most cases, these researchers are not adequately represented on agricultural experiment station staffs.

To achieve maximum expansion of knowledge in these areas, research must contribute fundamental and basic information and not be restricted to applied studies of limited usefulness. The "why's" must be understood, as the "how-to-do-it" is developed.

Communication needs to be strengthened among all who have responsibility for research in these areas—agricultural experiment station directors, home economics administrators, department heads, and research personnel in the many associated dis-

ciplines. Better communication can bring together the complementary academic skills needed for tackling vital problems and acquiring the necessary specialized facilities.

The traditional pattern of relationship between research scientists and teachers, including extension personnel, should be strengthened. Research findings contribute to sound teaching; experiences in the community and classroom suggest and clarify significant research questions.

Every effort should be made to expand the scope and improve the quality of the studies by agencies and institutions responsible for educational, service, and action programs designed to improve the quality of living. The various units of the land-grant colleges and universities, including the agricultural experiment stations in cooperation with the Cooperative State Research Service, share an important role in this responsibility.

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"An historical sense is one which is so formed that, in seeking to estimate contemporary merits and deserts, it knows how to take account also of the past."

JOHANN WOLFGANG VON GOETHE
1749–1832

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